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VOLUME II

FINAL ENVIRONMENTAL IMPACT STATEMENT

Eastern Powder River Coal Basin of Wyoming

CONTENTS

This is Volume II. It contains Chapters V through XI of Part I, the regional analysis.

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Chapter

CHAPTER V

PROBABLE CUMULATIVE REGIONAL IMPACTS

The analysis developed in this environmental impact statement is based on 1990 projections. The cumulative environmental impact is quantified, to the extent possible with existing data, only to this time period. The probability is recognized that, based on current leaseholds and investments, the pattern of resource development and growth will continue after 1990, though at modest rates. Cumulative environmental impacts will also increase but will be of variable quantity as indicated in the assumptions and criteria for analysis. While further projections and predictions are possible with ever decreasing levels of confidence, the time frame and geographic area parameters (Chapter I) were established at the outset of the analysis. If differences occur over time, the impacts analyzed in this section can be scaled up or down through use of the assumption and analysis guidelines (Chapter II). This will provide a better picture of the developing situation.

If the magnitude is scaled upwards, impact on certain environmental components would probably be more than on others. Those most likely to be affected are: air quality, soils, water resources, vegetation, wildlife and fish and agriculture.

In the impact chapters of the regional and site specific analyses, it must be strongly emphasized that the full impact on the environment, whether singular or cumulative, is quantified or qualified to the fullest extent assessible without imposing any management constraints that would mitigate, minimize, negate or divert these effects as they pertain to the proposed action(s). Such an evaluation is made with the recognition that certain results will not occur since they are precluded by agency resource management responsibility. The full report, in other chapters, contains

the required and probable mitigating measures to be applied if the proposals are approved along with impacts which cannot be feasibly avoided.

Projected development to the year 1990 within the study area will consist of: ten mines with plans to produce 296 million tons of coal by 1980, increasing to 12 mines, 858 million tons by 1985 and 14 mines and 1,543 million tons by 1990; construction and operation of a 330-megawatt air-cooled power plant, and a 250-million cubic feet per day gasification plant by 1980, a 450-megawatt air-cooled and a 500-megawatt water-cooled power plant as well as a second 250 cubic feet per day gasification plant by 1985 and another 500-megawatt water-cooled power plant by 1990; construction of 16 miles of road, 44 miles of powerline, 30 miles of coal slurry pipeline, 140 miles of rail line by 1980, 20 miles of road, 164 miles of powerline, 145 miles of rail line by 1985, and 24 miles of road, 225 miles of powerline and 150 miles of rail line by 1990, all of which will cause various impacts on the environment and its individual components.

Employment, construction and permanent, resulting from these developments will cause population increases of: 27,000 by 1980, 42,000 by 1985 and 47,000 by 1990 in the study area. These increases in population will require associated facilities such as schools, sanitary land fills, sewage plants, increased social services, all having additional environmental impacts. Population in the surrounding six-county area is projected to increase only moderately: 10,000 by 1980, 11,000 by 1985, and 13,000 by 1990.

It is acknowledged that not all environmental impacts associated with this development are confined to the State of Wyoming. If coal is exported from the study area to such places as Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Louisiana, Nebraska, Oklahoma and Texas, impacts

from energy conversion will occur in those areas. The exact nature of these impacts is not reasonably foreseeable due to the inability to fully anticipate how and under what conditions the coal and energy will be utilized. It should be noted that the impacts resulting from consumption of coal in electric power plants outside of the study area may be similar to the impacts of consumption of coal for electric power generation within the study area, varying essentially with respect to the degree of impact in relation to environmental conditions existing in those areas. Environmental impact of the use of coal and energy developed in the study area will be analyzed at the time other major federal actions are required or as necessary in these states to meet their environmental quality act requirements.

Climate

Development of a number of coal mines, power plants and gasification plants, and disturbance of significantly large areas of land surface may cause significant changes that could detrimentally affect weather and climate.

Recent studies indicate that large urban-industrial areas do affect precipitation. However studies have not been conducted in semi-arid climates; therefore, potential effects are inferred from theoretical relationships and knowledge concerning precipitation mechanisms and studies of climate modification in other areas.

Two potential major consequences of large scale energy development may lead to significant inadvertent modification of the regional weather and climate. These are increases in atmospheric particulate loading and changes in natural land surface characteristics which affect the precipitation mechanism.

Some evidence indicates that changes of atmospheric particulate loading and alteration of the earth-atmospheric energy balance may contribute to creation of drought conditions in semi-arid climates (Charlson and Pilat 1969; Bryson 1972; Mitchell 1971; Huff, Changnon 1973). Reduction in precipitation could have severe affects on agricultural productivity, mined land reclamation and water supplies within the region.

Air Quality

Complex source air pollution

Development of numerous coal mines, power plants, residential areas and disturbances of large areas of land will create multiple sources of various air pollutants. Since air pollutants originate from many sources, effective control would be more difficult than if a single pollution source were involved.

Development actions as outlined could generate dust and other suspended particulate matter from physical activities and chemical pollutants such as hydrogen sulfide, sulfur oxides, nitrogen oxides, carbon monoxide, photochemical oxidants, hydrocarbons, trace elements and radionuclides from processing operations. These pollutants from complex sources may have an adverse impact on existing air conditions in and adjacent to the study area. Impacts could increase rapidly during the period of 1974 to 1980 (seven new mines, a new 330-MW power plant, a gasification plant, 27,000 increased population, 230 miles of new rail line, roads, pipelines, powerlines, with 8,900 acres disturbed) and 1980-1985 (two new mines, two new power plants, one new gasification plant, 15,000 more people, 129 more miles of roads, rail line, powerlines and 10,900 more acres disturbed) and possibly level off during the 1985 to 1990 time period (two more mines, one more power plant and 5,000 more people, and 9,200 more acres disturbed).

Plant stack emissions

Potentially, the most serious cumulative impact on air quality, with possible adverse impact on humans, animals and vegetation, is from stack gases emitted by four new coal-fired power plants and two coal gasification plants. Emissions include sulfur oxides, nitrogen oxides, carbon monoxide, hydrocarbons, hydrogen sulfide, photochemical oxidants and particulates.

Projected development during the period of 1974 to 1980 shows construction of a new 330-megawatt (MW) power plant at Wyodak and retirement of

units 1, 3 and 4 of the Neil Simpson Station. Assuming the new plant and Neil Simpson Unit 5 (20-MW) meet New Source Performance Standards (NSPS), projected annual emissions at Wyodak could be: 1,600 tons of particulates (P), 15,700 tons of sulfur dioxide (SO_2), and 12,400 tons of nitrogen oxides (NO_x).

During this same time period construction of a coal gasification plant to produce about 250-million cubic feet per day is expected. This plant (with 325-MW companion power plant) is expected to produce yearly, 23,800 tons of sulfur dioxide, 11,400 tons of nitrogen oxides, 39,500 tons of hydrocarbons (HC), and 2,100 tons of particulates. (Assuming compliance with NSPS and Wyoming Air Quality Emission Standards.)

By 1985 projected development will include a new 500-MW power plant, and a 450-MW power plant at Wyodak which could produce an estimated yearly emission of 4,400 tons of particulates, 40,400 tons of sulfur dioxide, and 30,600 tons of nitrogen oxides. Also a second coal gasification plant is projected by this time. This plant will have a type and amount of emissions similar to the plant projected for the 1974 to 1980 time period. (Assuming compliance with NSPS and Wyoming Air Quality Emission Standards.)

Another 500-MW coal-fired power plant is expected to be in operation by 1990. This plant is expected to have emissions of 2,300 tons of particulates, 21,400 tons of sulfur dioxide, and 16,100 tons of nitrogen oxides. (Assuming compliance with NSPS and Wyoming Air Quality Emission Standards.)

Some projected potential cumulative emissions during the period 1980 to 1990 are shown in Table 1. Quantities are based on the assumption of new power plants (other than at Wyodak) of 500-MW size, 250 million cubic feet/day gasification plants, and emissions meeting maximums permitted under New Source Performance Standards for Steam Generators, and Wyoming Air Quality Emission Standards.

Based on expected siting of new plants, the areas near Gillette (two power plants and one gasification plant) and Douglas (one gasification plant) could be adversely affected by cumulative stack emissions. With a prevailing northwest wind direction (upper level), other towns that could be impacted by such emissions include Moorcroft, Lusk, Newcastle, Guernsey, Torrington, Wheatland, and Sundance, Wyoming; Custer, South Dakota; and Scottsbluff, Nebraska. However, most impacts would likely occur within 10 to 20 miles of the plant sites, where pollutant concentrations are usually highest, and this would make Gillette and Douglas most vulnerable.

Vehicle and equipment emissions

Industrialization of the study area and attendant population increase (27,000 by 1980, 42,000 by 1985, 47,000 by 1990) will increase use of internal combustion engines of all types. Engine emissions will result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides and sulfur oxides to the basin air. These emissions are potentially harmful to the health of basin residents, vegetation and animal life. Much of the vehicle and equipment emissions will be contributed by railroad locomotives. Table 2 gives some estimated cumulative locomotive emissions for 1980, 1985, and 1990.

Dust and similar particulate matter

Increases in airborne dust and similar particulate matter (coal dust, fly ash dust, etc.) will result from described development activities. The increased possibility of coal fires and wildfires will increase the possibility of additional toxic pollutants in the air, especially from coal fires. Pollutants resulting from coal fires will be similar to those from a coal-fired power plant.

Airborne particulate matter could reduce visibility and possibly cause traffic accidents during periods of inversions and periods of high winds.

Table 1

Some Potential Cumulative Emissions in the Study Area

	Emissions by Year - 1,000 tons per year											
	1980				1985				1990			
	P	SO_2	NO_x	HC	P	SO_2	NO_x	HC	P	SO_2	NO_x	HC
Dave Johnston P.P. (750-MW*)	3.5	30.6	24.2		3.5	30.6	24.2		3.5	30.6	24.2	
Neil Simpson P.P. (20-MW**)	0.4	1.4	1.3		0.4	1.4	1.3		0.4	1.4	1.3	
Wyodak P.P. (new 330-MW***)	1.2	14.3	11.1		1.2	14.3	11.1		1.2	14.3	11.1	
Wyodak P.P. (new 450-MW#)					2.1	19.0	14.5		2.1	19.0	14.5	
First new 500-MW P.P.#					2.3	21.4	16.1		2.3	21.4	16.1	
Second new 500-MW P.P.#									2.3	21.4	16.1	
Panhandle Eastern Gasification P.##	2.1	23.8	11.4	39.5	2.1	23.8	11.4	39.5	2.1	23.8	11.4	39.5
Second Gasification Plant ##					2.1	23.8	11.4	39.5	2.1	23.8	11.4	39.5
Cumulative Totals	7.2	70.1	48.0	39.5	13.7	134.3	90.0	79.0	16.0	155.7	106.1	79.0

*Existing power plant -- assumption that retrofit program for particulate control will be completed by 1977.
**Existing power plant -- Unit 5 only (Units 1, 3 & 4 to be retired in 1977).
***Source of data for new power plant -- Environmental Report dated May 1973, Black Hills and Pacific Power and Light Companies.
#Emissions for new power plants based on maximums permitted under compliance with New Source Performance Standards (NSPS) for Steam Generators and Wyoming Air Quality Emission Standards.
##Emission estimates include companion 325-MW power plant; estimates based on compliance with Wyoming Air Quality Standards.

P-particulates SO_2-sulfur dioxide NO_x-nitrogen oxides HC-hydrocarbons

Year	Coal Hauled		Diesel Fuel	Estimated Cumulative Emissions-tons per year***				
	Unit Trains/year*	Million tons/ year	per day-1000 gals.**	Particulates	Sulphur Dioxide	Nitrogen Oxides	Carbon Monoxide	Hydro-Carbons
1980	4,364	48	58.3	266	606	3,937	1,383	1,000
1985	6,182	68	84.1	384	875	5,679	1,995	1,443
1990	8,455	93	112.5	513	1,170	7,597	2,669	1,930

*Loaded trains. Same number of empty trains would be required.
**Fuel requirements include loaded and empty trains.
***Assumed to operate 365 days per year. Also includes loaded and empty trains.

Source: Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, Table 3.2.2-1 EPA Publication No. AP-42, April 1973.

Table 2

Estimated Cumulative Emissions from Locomotives in the Study Area

High winds are frequent but inversions over two-day periods may occur as many as 15 times per year. Particulate matter could also contribute to human allergies and similar irritations and coat vegetation with potentially harmful chemicals.

Based on the prevailing upper level wind direction (northwest), the impact from the increased airborne particulate matter could affect the communities and towns of Gillette, Moorcroft, Douglas, Lusk, Newcastle, Guernsey, Torrington and Wheatland, Wyoming; and Scottsbluff, Nebraska.

Summary

Identification and quantification of impacts with precision is not possible until each system has been designed and a quantitative analysis performed. Prior to construction of each of the facilities, such an analysis will be conducted. However, based on assumed rate and type of development certain qualitative impacts can be predicted for the study area.

Industrialization and development of the study area will result in a decline in ambient air quality. A general decline will occur from 1974 to 1980, with a more serious decline during the 1980 to 1985 period. The rate of decline is expected to level off after 1985, since by this time the major projected development will have leveled off with only minor increases proposed for the 1985 to 1990 time period. The decline of air quality will remain fairly constant for the rest of the time period (1985-1990).

Increased plant stack plumes and haze from disturbed soil and coal dust will result in poorer visibility within the basin and possibly in areas to the east and southeast of the basin.

Emissions could cause localized damage to vegetation and animals over a long time period. Damage to ponderosa pine after exposure to SO_2 has been reported (HEW, Air Quality Criteria for Sulfur Oxides, January 1969). Similar vegetation is found in the Black Hills National Forest around Newcastle and

Sundance, Wyoming and Custer, South Dakota; the northeast portion of the Thunder Basin Grassland in the vicinity of Upton and Osage, and in the Rochelle Hills area. Ponderosa pine is prevalent in these areas. The Upton and Osage areas already experience a reduction in air quality due to emissions originating from betonite plants in the vicinity. Addition of emission from the study area may compound the impact in that vicinity. Effects of emissions on vegetation and animals are not well understood at this time, and research efforts are underway to determine possible adverse effects.

Trace elements, including radionuclides, contained in coal burned by power plants in the study area may be released with stack emissions. Such emissions could have a detrimental effect upon soil, vegetation, animals, and man although little scientific information exists as to their effects on the environment.

An increase in atmospheric sulfur is believed to have resulted in acid precipitation in the northeastern United States as reported by Likens and Bormann (1974). Emission of sulfur dioxide (SO_2) by power plants and gasification plants proposed for the study area could cause a similar problem in the study area and have an adverse effect on the environment, including plants, fish, and metal structures (as reported by Likens and Bormann). However, this is not considered likely.

Photochemical oxidants (smog) may be formed when nitrogen oxide emissions from power plants combine with certain hydrocarbon emissions from gasification plants and sunlight. This pollutant may form from proposed power and gasification plant emissions.

Emissions could have injurious and toxic effects on humans working or living in the vicinity of power and gasification plants in case of accidents or during periods of severe or repeated inversions. Throughout the basin there is a probability of a two-day inversion occurring 15 times per year, and a

five-day inversion occurring four times a year. (Observations by Marwitz indicate persistent winter inversions -- Hearings statement 6-26-74.) Impacts on health could result from long or repeated exposures to any severe air contamination during inversion episodes.

Present ambient air quality in the study area is good, but it will decline with the development of complex pollution sources as industrialization takes place.

Topography

The removal of coal during mining operations will decrease altitude of the land surface to varying degrees and thereby locally create sharper relief or flatten the slope of the land. New landforms will emerge from coal removal owing to placement and type of reclamation of spoil materials and to erosion and redeposition of spoils. Surface mining will increase soil movement, change drainage patterns and size, shape, and position of topographic features. Spoil ridges from mine cuts will be subject to erosion, and erosion may increase locally within pits. Both water and wind are active agents of erosion and deposition and require some form of control in the vicinity of mining operations.

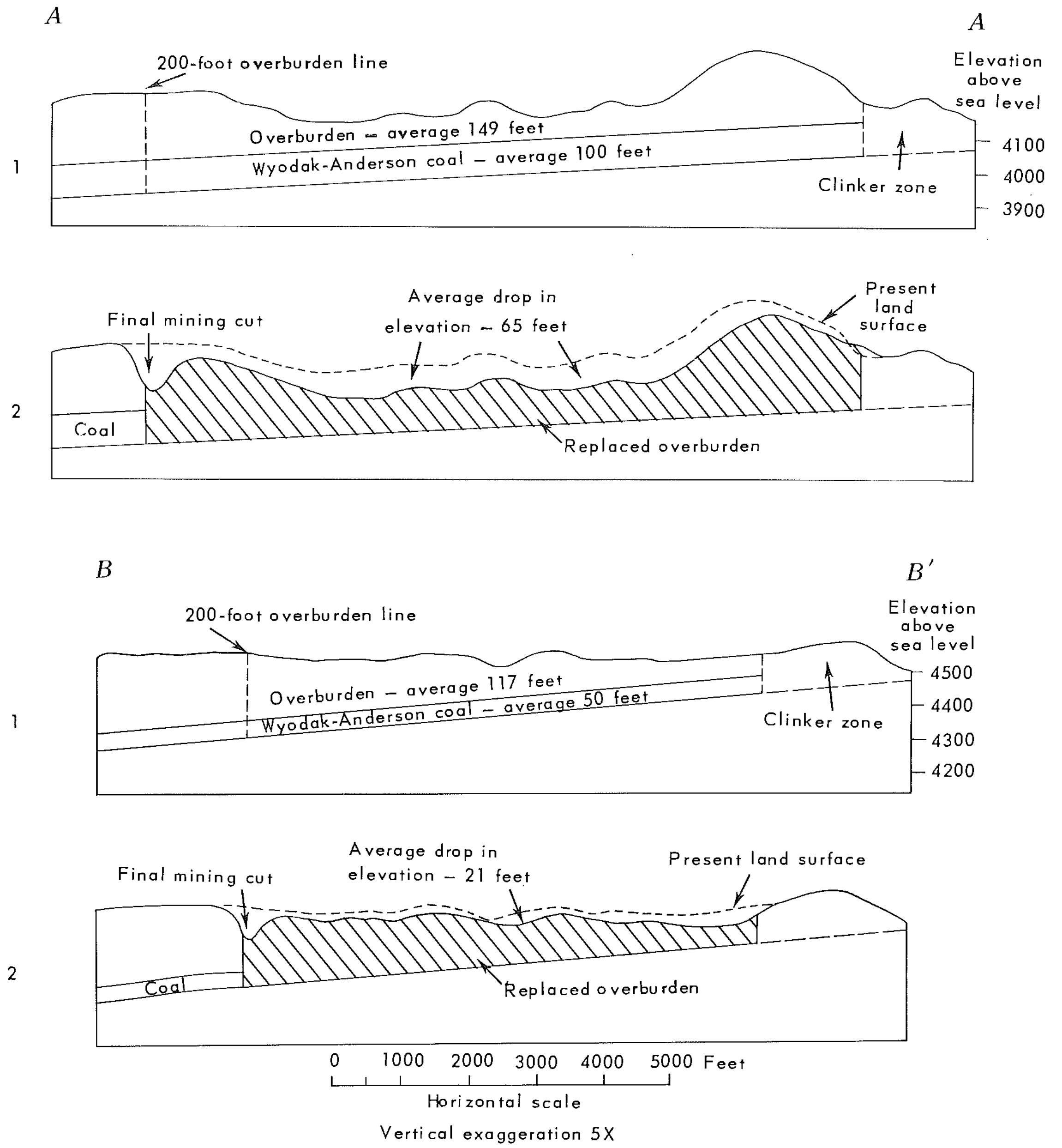
Mining of coal, 296 million tons by 1980, 858 million tons by 1985 and 1.5 billion tons by 1990, will significantly impact the topographic shape of the area mined to recover this coal. By 1990 surface mining will have impacted an estimated 14,000 acres. Each year the slow pace of mining thick coal, even at a high annual rate of 118 million tons, alters only a small fraction of the area that will be disturbed. For example, large mining operations which remove coalbeds about 60 feet thick to produce 17 1/2 million tons of coal annually would disturb only about 165 acres per year. At any period about 445 acres, dependent upon the amount of overburden prestripping necessitates and excluding roads and facilities, would be disturbed by each mining-reclamation operation. Such a situation could comprise 100 acres being prestripped, 165 acres being mined, and 165 acres being smoothed and reseeded. With an estimated production of 118 million tons of coal per year, an average of seven operating mines could annually disturb as much as 3,000 acres in a single year, but over a 15-year period, probably not more than an average of 1,200 acres.

The surface would also be altered, but to a lesser degree, by construction of 24 miles of new roads and 150 miles of new rail lines by

1990. Disturbances from this type of activity will involve about 3,600 acres by that year. Some alteration of land surface will also result from construction of gasification plants, power plants, and reservoirs. Mining and removal of clinker, sand, and gravel to meet construction needs of these activities will also cause minor changes to the land surface. Acreage impacted by this construction is indeterminate at this time.

The removal of coalbeds, ranging in thickness from 20 feet to 120 feet, will result in an overall lowering of the land surface on which this removal takes place. The average overburden thickness which covers the coal ranges from a few feet to 200 feet. During mining, the overburden is broken up and turned over which increases its volume by 20 percent. This increase in volume, however, is not enough to compensate for the removal of thick coalbeds. Figure 1 gives an example of the decrease in altitude which could result from coal removal. In Part A of Figure 1 the overburden averages 149 feet and the coal seam averages 100 feet for a total thickness of 249 feet. The 100 feet of coal is removed. The overburden is increased 20 percent in volume or from an average thickness of 149 feet to 179 feet. The corresponding decrease in altitude of the land surface is the difference between coal thickness (100 feet) and the increased volume (30 feet) or 70 feet. Some coal remains with the spoils because of mining tolerances (90 to 95 percent recovery of coal); thus, this example of 100 percent coal recovery produces a maximum depression.

A reduction in altitude of the land surface can occur wherever coal is mined. Some average altitude changes in the coal mining area from north to south in the study area are about 54 feet at the North Rawhide mine (see Part IV), about 68 feet at the Wyodak mine (see Part VI), about 36 feet at the Black Thunder mine (see Part III), about 38 feet at the



1-Conditions before mining

2-Conditions after mining; overburden is replaced on a cut-by-cut basis (assuming 200-foot wide cuts) and smoothly graded; remaining walls are graded to 3:1 slopes.

Figure 1

Diagrammatic Sections Showing Potential Changes in Topography Resulting From Surface Mining

Jacobs Ranch mine (see Part V), and about 28 feet at the proposed Rochelle mine. A typical mining-reclamation operation illustrated in Figure 2 shows the surface before mining, the placement of spoils, and the change in altitude of the land surface after mining coal in the southern part of the coal mining district. Here a similar undulating surface may remain after mining. The reduction of the highwall covers the coal but leaves a small lake in a residual depression.

In some areas where the coalbed is very thick, such as the Wyodak bed around Gillette, and the overburden is thin, sufficient overburden may not be available to fill the final mining pit. This partially filled final pit will result in the formation of lakes or partly waterfilled depressions throughout the thick coal area. East of Gillette, Donkey Creek may be partly ponded or trapped in this broad depression caused by coal mining as indicated by pre- and post-mining altitudes along the creek (see Part VI).

Besides a general lowering of topography, appearance of the area may be changed. Assuming no reshaping of spoil but only smoothing, the result will be a broad lowering of the land surface that ends in a long narrow trough at one end of the mine. This is the final pit and highwall. Terrain remains rolling but subdued because cliff-life or abrupt breaks in the landscape cannot be recreated. The final landform may be similar to the surrounding undisturbed area unless the spoils are drastically smoothed and ravines filled by material from ridges (see North Rawhide mine, Part IV)

Mining causes changes in drainage patterns by altering channels and surface slope or gradient. Truck and shovel operation, presently considered by most of the mining companies, produces a smoother, lower-gradient terrain that is locally more favorable to revegetation and decreased erosion. This type of mining operation affects a smaller area per year, results in closer

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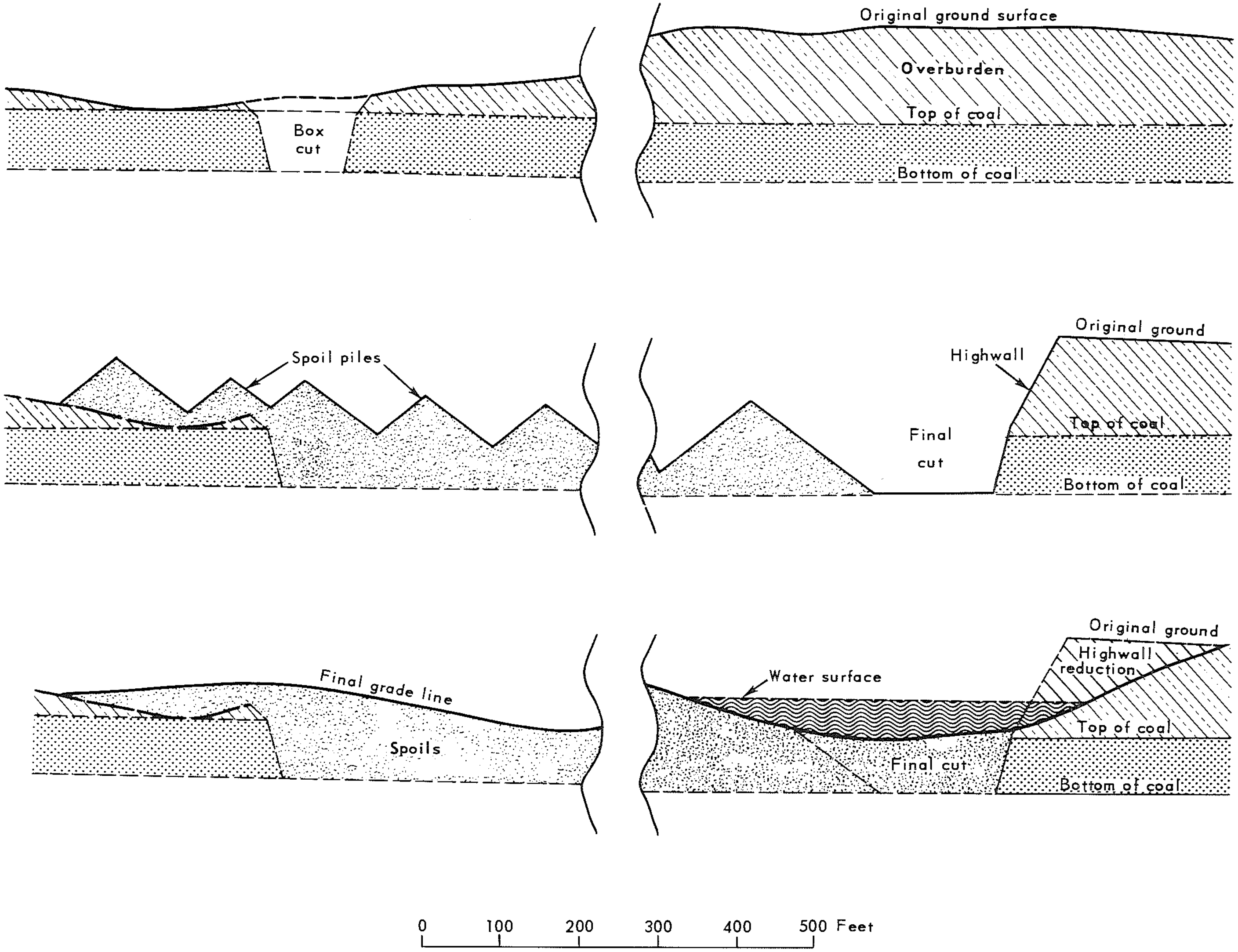


Figure 2
Typical leveling of spoils and change in altitude of the land surface after mining coal in southern part of the coal mining district

control of the final surface altitude and allows optimum recontouring after mining. The smooth terrain decreases channeling and headward erosion of existing channels, and minimizes the effect of sheetwash resulting from thunderstorms. Although truck and shovel operation decreases the size of the mining-reclamation operation, unprotected broken sandstone in spoil piles produces an available source of fine sand particles. At wind velocities above 20 miles per hour, saltation becomes an effective means of transport and removal of the sand. Wind can easily erode loose dust from broken playa material, road material, bare spoil piles, and soil stockpiles if these temporarily exposed surfaces are not protected by water or grass. Windblown material could form small local dunes, such as the high level sand dunes near Glenrock, which would add a new dimension and shape to the landscape.

Construction of roads and rail lines will alter topography along the rights-of-way. This change in surface is especially true of rail lines if a maximum grade of one percent is maintained. This causes deep cuts in the landscape, ranging from 40 to 102 feet deep on the proposed mainline right-of-way. Roads will require cuts, but they will be of less magnitude than caused by the railroad.

Soils

Development of coal resources and attendant facilities will cause a significant impact on soils within the area disturbed by mining. The major impact will result from actual mining operations to remove 296 million tons of coal by 1980, 858 million tons by 1985 and 1,543 million tons by 1990. This will result in disturbance and mixing of the topsoil on approximately 14,000 acres by 1990. Disturbance will alter soil characteristics, micro-organisms and soil climate relationships which have been established over a long geologic time span. The current level of soil productivity will be lost for an indefinite period. Impact on topsoil increases in proportion to the increased mining rate. The topsoil disturbance per five-year period accelerates from 2,700 acres in the 1974 to 1980 period to 5,000 from 1980 to 1985 and 6,300 from 1985 to 1990. Some properties of topsoil will be destroyed by mining on 14,000 acres by 1990. This represents approximately 0.3 percent of the surface in the study area. Further mining would extend the impact beyond that level.

Mining involves removal of large volumes of overburden to reach coalbeds. Removal of overburden will result in complete alteration of soil horizons, parent material and soil characteristics. It could result in bringing to the surface elements, such as boron, which may be toxic to plant growth. At completion of mining operations, soil structure will be completely different from what it was prior to start of mining operations. Table 3 presents some idea of the volume which will be disturbed over the 14,000 acres mined for coal.

Table 3

Cumulative Volume of Overburden Disturbed

Year	Million Cubic Yards
1980	266.4
1985	772.2
1990	1388.7

In addition to the area of soil which will be disturbed by actual mining, soil disturbance will also result from construction of railroads, access roads, transmission lines, mine facilities, power plants, gasification plants, coal slurry pipeline, pipelines and new housing facilities. Much of this disturbance will result in permanent loss of productive soil surface. Soil surface disturbed and permanently removed by these activities is shown in Table 4. The impact of permanent soil surface loss is greatest in the 1974 to 1980 time period when 4,800 acres are lost to facility construction.

Table 4

Cumulative Soil Surface Acres Disturbed
and Permanently Removed from Production

	Cause of Disturbance			
Year	Rights-of-Way	Facilities & Housing	Total	Permanently Removed
1980	3,100	3,100	6,200	4,800 (77%)
1985	6,000	6,100	12,100	7,900 (65%)
1990	7,500	7,500	15,000	9,500 (63%)

Without knowing the precise location of the disturbance on a yearly basis, it is difficult to determine which soil associations may be impacted. Since locations are known with a fair degree of accuracy for 1980, disturbed

acreage by soil associations were calculated. The data shown for the subsequent years is based on a simple proration formula. Table 5 includes acreages disturbed by all types of activities from 1980 to 1990. The table also includes acreage permanently removed which cannot be separated with the data available at this time (April 1974).

All of these disturbances will result in fine grained soil and parent material being exposed to wind and water actions. Soil productivity, permeability and infiltration rates will be reduced, increasing runoff, soil erosion and sedimentation. Wind action, which is almost constant over the entire area, will cause fine soil, silt and clay particles to be lifted into the atmosphere reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms will remove fine materials and can result in formation of gullies. Alteration of stream channels and increased velocity will accelerate erosion of stream banks and cause headcutting of the streams. This will add to soil loss and sedimentation.

Increased population within the study area (27,000 by 1980, 42,000 by 1985, and 47,000 by 1990) will cause other losses to soil values. Greater recreation use, originating from more population, will cause additional soil losses. Any increase in off-road vehicle use could cause serious impact on soils.

Even though land is reclaimed, soil will be lost and productivity reduced on 0.6 percent of the study area by 1990. As this loss will take place in probably the most productive area of the Eastern Powder River Coal Basin, the loss could be significant.

Table 5
Cumulative Soil Surface Acreage Disturbed by Association

Year	Soil Association Number* 1	3	7	8	9	10	11	13	14	19	20	Total
1980	213	3,319	214	698	240	144	1,821	247	295	210	1,499	8,900
1985	474	7,384	476	1,553	534	320	4,052	550	656	467	3,334	19,800
1990	690	10,815	697	2,274	782	469	5,933	805	961	684	4,886	29,000

*Refer to Chapter IV for description and name of each soil association.

Mineral Resources

The most important regional impact on minerals by the active and proposed mining and transportation operations is the impact on coal. Great tonnages of coal will be mined from the Eastern Powder River Coal Basin and used in the basin or exported. Most coal consumed as fuel within the basin is for the production of electric power or synthetic gas, much of which will be exported to consumers. Thus, the main impact is the removal and subsequent combustion of 1.5 billion tons of coal by 1990. This coal production will result in the depletion of a nonrenewable energy resource.

Some coal will be lost during mining, mostly by leaving fenders of coal to block spoil piles from working faces in areas where the mining situation dictates coal recovery is most efficient in narrow panels. This denial of coal can be temporary, and the subsequent impact minor because these fenders can be recovered before mining is completed.

An impact on coal could arise from the proposed location of the railroads. The proposed mainline will be located above coalbeds which are amenable to mining by surface and underground methods. The mainline right-of-way crosses an estimated 161 million tons of economically strippable coal. Should it become economically feasible to strip overburden to depths of 400 feet, then the proposed right-of-way would cross an additional 195 million tons of coal. The spur lines to be built into the mines will cross additional large amounts of strippable coal (Table 6).

Resources crossed by the railroad will not undergo impacts of loss but rather nonproduction to the extent that mining is not permitted.

Table 6

Coal Resources and Associated Overburden Along the Proposed Railroads and Spurlines

Overburden thickness Range in feet	Length of rail line in miles	Average thickness of coal in feet	Coal in millions of tons
Proposed line			
0-200	18.5	40.5	160.8
200-400	13	70	195.1
over 400	15+		
West alternate line			
0-200	4	48.5	41.6
200-400	15.5	56.4	187.6
over 400	25+		
Mainline spur to North Rawhide mine			
0-200	0.5	50	5.4
200-400	0		
over 400	0		
Proposed line spur to Black Thunder and Jacobs Ranch mines*			
0-200	3.5	70	52.6
200-400	1	70	15.0
over 400	1		

*Add 2.0 miles of over 400 feet of overburden to these data for the spur to the alternate line.

Moving of spur lines to allow mining commonly takes place, so that the only impact of these lines on coal will be expense and time associated with having to relocate them prior to mining operations. Realignment of the mainline would be more expensive to accomplish and may not take place for decades.

The second major impact on minerals, resulting from mining of 1.5 billion tons of coal by 1990, will be from construction of facilities to support the coal mining and utilization. Significant utilization impacts will occur on aggregate materials. A plentiful supply of clinker is available from local sources near the burnline. Some sand and gravel is available from local streambeds. These materials will be consumed in foundations, structures, subgrades, road surfacing, and railroad ballast. Impacts will occur within and outside the study area. Aggregate will be imported from the Buffalo and Newcastle, Wyoming, areas and by rail from distant quarries.

The magnitude of this impact can best be illustrated by the following examples. Based on a silo height of 193.6 feet, an inside diameter of 70 feet, 1 foot thick walls, top slab 6 inches thick, and a base, the silo contains a total of 4,000 cubic yards of concrete and holds 12,000 tons of coal. Based on a typical design to obtain the necessary strength, approximately 3,600 cubic yards of sand and gravel would be required in construction of the silo. Assuming that one 193.6-foot tall silo is required per 1.5 million tons of coal mined per year, Table 7 shows the estimated sand and gravel needed for silos.

Table 7

Sand and Gravel Required for Silos

Year	Increase in Coal Production*	No. of Silos	Cumulative Cubic Yards of Sand & Gravel
1975	6	4	14,400
1980	83	55	198,000
1985	113	75	270,000
1990	145	97	349,200

*Increase based on 1973 base of 5 million tons, assumed that all coal is exported.

Therefore, for silos alone a total of 349,200 cubic yards of sand and gravel will be required by 1990. Additional material will be required for other numerous concrete structures to be built. The amount of surface which will be disturbed is undetermined. Only limited supplies of sand and gravel are found in the study area; therefore, most of this material will have to be imported. Most of the sand and gravel obtained in the area will come from streambeds within the study area impacting fish habitat and water quality.

Local clinker deposits will be utilized for subballast (roadbed) on the rail lines to be constructed. Assuming that 6,600 cubic yards will be required per mile of rail line, including road crossings, the cumulative amounts required will be: 1980 - 924,000 cubic yards, 1985 - 957,000 cubic yards and 1990 - 990,000 cubic yards, equivalent to about 61 acres of clinker about 10 feet thick. The impact on the total available clinker is negligible.

New roads will be constructed, each requiring use of aggregate material such as gravel, sand, and clinker. As state and county road construction will be involved, an estimate of aggregate needs is difficult to calculate,

but assuming that on an average 6,000 cubic yards are required per mile of road, the cumulative amounts required will be: 1980 - 96,000 cubic yards, 1985 - 120,000 cubic yards, and 1990 - 144,000 cubic yards, equivalent to nine acres of clinker 10 feet thick.

These few examples illustrate a cumulative need of 1.5 million cubic yards of material to be used by 1990 but represent only a small portion of the total demand that will have to be accommodated. The majority of the material will come from within the study area.

No known conflicts exist between actual or proposed mines and areas of oil and gas production. Most presently producing oil and gas wells in areas of proposed mines will be exhausted, plugged, and abandoned prior to mining. Oil and gas exploration and development can follow mining and reclamation without difficulty. Deferring oil and gas production until mining is completed may impact supply, but no loss would occur. The magnitude of this impact cannot be quantified at the regional level but it is not expected to be significant. Impacts with respect to well siting, flowlines, pipelines, treaters, separators, and tanks are mostly avoidable or easily and quickly negotiated. Railroad construction through producing areas is not expected to cause significant impact on oil and gas.

Uranium-bearing rock exists in overburden in some places and will be subject to impact from mining and construction projects. The major area of impact would be north of Douglas in the southern part of the study area. The Energy Resources map, No. 4 in Appendix A, shows locations where uranium and strippable coal deposits overlap. Uranium ores encountered or discovered during or prior to coal mining operations will be mined. Some uranium-bearing

material might be recovered that normally would not be mined because fragmentation and removal of overburden necessary to the mining of coal might enable economic uranium recovery.

Some minor amounts of uranium-bearing rock could be diluted during operations and construction and lost to further efforts of recovery. Some material may be covered by spoil or permanent structures and temporarily denied to examination and recovery. The magnitude of this impact is minor.

The cumulative impact on mineral resources through the year 1990 will be significant. By 1990 an estimated 12 percent of the presently economically strippable coal reserves will have been removed. The availability of sand and gravel material within the study area will be scare and commercially mineable deposits may be nonexistent.

Water Resources

Water supplies

Water is a resource that affects most facets of economic, social, and environmental conditions. Development of water supplies for northeastern Wyoming's coal and other energy resources could have a tremendous impact on all these facets. Because water can be transported from areas of supply to areas of demand, consideration must be given not only to water requirements of the Eastern Powder River Coal Basin but to those of the remainder of the Powder River Basin and to all possible sources of water, including imports from other basins.

Development of the Eastern Powder River coal deposits will have major but varying impacts on the water resources of the area depending upon how the coal will be utilized. Developing a water supply for the mining of 1.5 billion tons of coal by 1990, development of coal slurry pipelines, gasification plants, and power plants, and associated population increases within the area will have the larger impact. Exportation of coal only would have lesser impact on water utilization again depending upon mode of transportation, i.e., rail or slurry line. The estimated present and projected water uses are shown in Table 8. The assumption is made that all the water listed as requirements will eventually be consumed or disposed of as unuseable wastes. Figure 3 graphically portrays the potential for water development in the Powder River Basin and the cumulative water requirements expected to occur between 1974 and 1990. Figure 4 shows the expected increase in water requirements from 1974 to 1990.

The cumulative increase in water demands over present levels for the study area is approximately 28,000 acre-feet per year by 1980, 47,000 acre-feet per year by 1985, and 50,000 acre-feet per year by 1990. The water requirements for land reclamation have not been satisfactorily determined; this activity needs extensive research and experimentation.

Table 8

Estimated Present and Projected Water Requirements for Largest Users of Water in the Study Area
and the Entire Powder River Structural Basin

Annual Water Requirements (acre-feet)

Type of Use	Study Area 1974	Study Area 1980	Study Area 1985	Study Area 1990	Structural Basin 1974	Structural Basin 1980	Structural Basin 1985	Structural Basin 1990
Irrigation	10,000	10,000	10,000	10,000	263,000	263,000	263,000	263,000
Reservoir Evaporation	30,000	30,000	30,000	30,000	85,000	85,000	90,000	90,000
Municipal**	8,000	15,400	18,600	20,000	21,000	29,000	32,000	36,000
Oil Field (water-flood)	12,000	12,000	12,000	12,000	17,000	17,000	16,000	16,000
Power Plants	8,430*	8,650*	14,150	19,650	9,000	50,000	75,000	100,000
Gasification Plants	0	7,000	14,000	14,000	0	25,000	32,000	44,000
Slurry Pipelines	0	15,000	15,000	15,000	0	15,000	30,000	45,000
Synthetic Liquid Fuel	0	0	0	0	0	7,000	42,000	60,000
Totals	68,430	98,050	113,750	120,650	395,000	491,000	580,000	654,000

*Includes Neil Simpson air-cooled and Dave Johnston water-cooled plants.
**Includes use outside of study area resulting from development in study area.

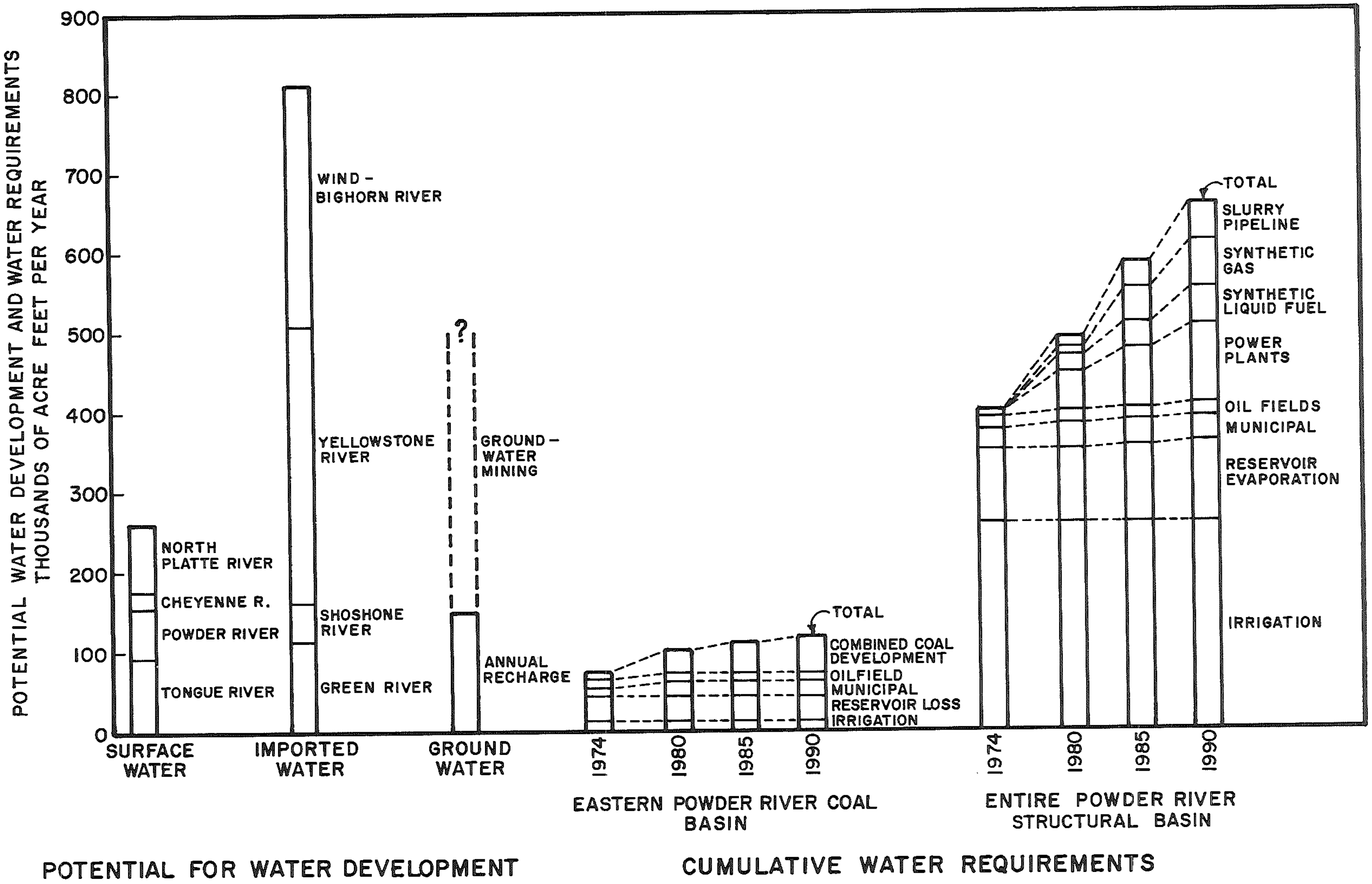


Figure 3
Potential Water Development and Water Requirements in the Powder River Basin, 1974 to 1990.

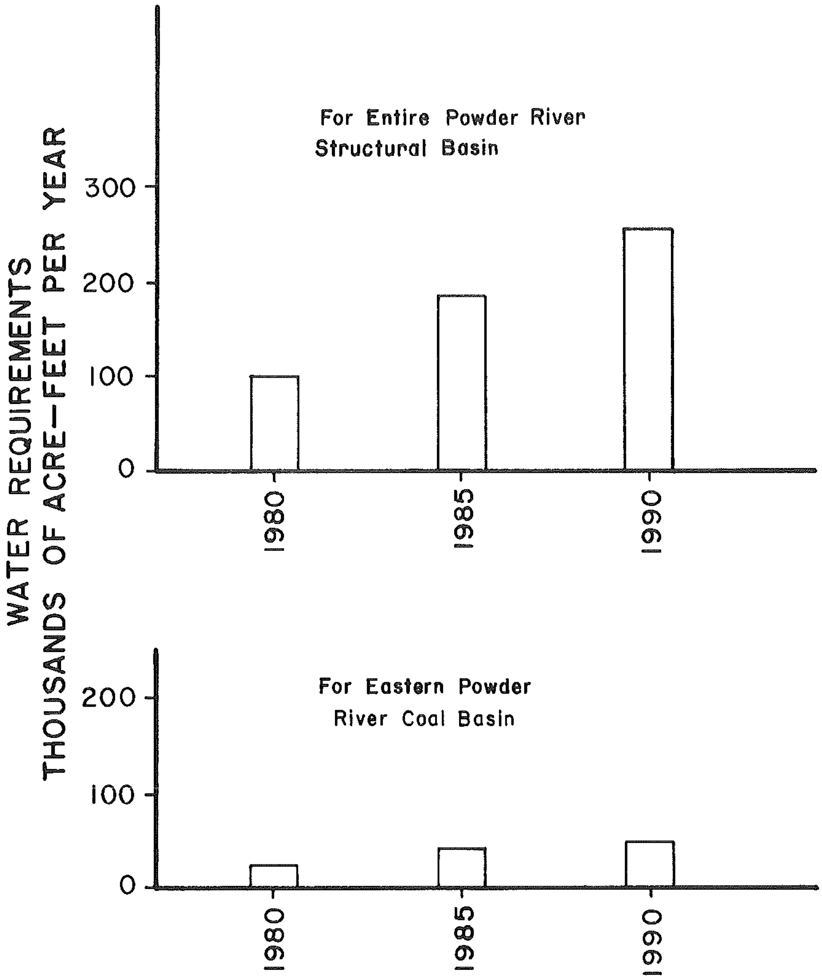


Figure 4

Projected Increase in Water Requirements

Planned coal developments require larger and more dependable water supplies than are presently developed in the study area. In order to fulfill this requirement, additional ground and surface water supplies may be developed, existing water uses may be changed, or water may be imported from other basins. Table 9 lists possible water sources available from current unused and unappropriated supplies.

Table 9

Potential Water Sources

	Acre-feet per year
Surface water	
Tongue River	96,400
Powder River	65,000
Cheyenne River	15,000
North Platte River	85,000
Ground water	
Use equal to annual recharge	150,000
Use greater than annual recharge	Unknown
Imported water	
Green River	120,000
Shoshone River	40,000
Yellowstone River	350,000
Wind/Bighorn Rivers	300,000

Water sources are available to meet the needs of the Eastern Powder River Coal Basin, but competition for these sources will occur from energy-related developments outside the area. Also, the quality of the various sources as well as the economic and environmental feasibility of their development must be considered by the individual companies.

The potential for ground water development for an infinitely long time is equal to annual recharge to the aquifers. Annual recharge (estimated

at 150,000 acre-feet per year) is more than enough to satisfy the total increase in demand for water (50,000 acre-feet per year by 1990) within the study area.

If desired, ground water development could greatly exceed 150,000 acre-feet per year by withdrawing ground water from storage in excess of annual recharge (mining of water). As described previously, several formations are capable of yielding 100 to 1,000 gpm of water to properly constructed wells. More than 3,000 gpm possibly could be obtained from individual wells that are open to all the aquifers from the top of the Fort Union formation to the base of the Madison Limestone in the study area. The depth to the base of the Madison ranges from about 8,000 feet in east central Campbell County to about 12,000 feet in southeastern Campbell County. With a spacing of one well in the center of each 40-acre tract (a distance of 1,320 feet between wells) and an assumed average yield of 2,000 gpm per well, each square mile would yield more than 52,000 acre-feet of water per year. This type of development in a little more than two square miles would supply the total requirements for the study area to 1990 (118,000 acre-feet per year) without depleting the ground water supply. In actual operations, the wells could be more widely dispersed, due to the dispersal of coal development activities, and the pumping lifts would be less.

Several companies, such as Energy Transportation Systems (coal slurry pipeline) and Panhandle Eastern Pipeline Co. (gasification plant), have indicated an interest in the use of ground water from the Madison Limestone. Other companies are exploring the shallower aquifers.

At this time, the proportion of water that will be obtained from ground water sources and from surface water sources has not been determined.

Each company is responsible for developing its own water supply, and each will be searching for and developing the most economical and dependable supply within the legal constraints of water rights.

Changes in the present surface water use of northeastern Wyoming could have significant effects on agriculture. Industrial companies have already purchased over 12,000 acres of irrigated lands with the intent of having the water rights changed from irrigation to industrial uses. Additional purchases are currently taking place as industries attempt to secure water supplies for their particular operations. Changes in the existing agricultural uses of this water would impact agriculture as well as wildlife populations.

Much of the water in the study area is not suitable for some uses, such as municipal, domestic, and boiler feed-water supplies, without desalting. Water quality requirements for other uses in the coal development industries have not been clearly specified. All the water in the study area probably would be acceptable for cooling and for use in slurry pipelines, but disposal of the residual cooling water presents serious problems. Dissolved solids are concentrated in the cooling water since part of the water is evaporated. Even though makeup water is introduced into the system, the concentration of dissolved solids in the cooling water eventually becomes so high all the water in the cooling system at that time must be discarded.

Possible alternatives for disposal of the cooling waste water are use for oil field flooding, evaporation from holding ponds, or injection into deep aquifers containing highly saline water. Use of evaporation ponds would still present a problem of solid waste disposal of the salt residue.

The salts could possibly be refined and marketed, but the market for such salts generally is poor. Otherwise, the salts would have to be transported to the ocean or other suitable site for disposal.

Disposal of sewage effluent from the increased population could present a similar problem. However, treated effluent probably will be used as a cooling water supply with the same disposal problems as described above.

Aquifers

Impacts during mining and reclamation

Mining will interrupt some alluvial and/or bedrock aquifers. By 1990, this disruption could occur on 14,000 acres or approximately three-tenths of one percent of the total study area. Backfilling will not restore the aquifer even though some of the fill becomes saturated. The best analogy to predict the water-bearing characteristic of the fill would be land-slide deposits, common in the northwestern part of the Powder River Basin. These deposits often have small springs and seeps at their base, but the deposits are too poorly sorted to be considered as sites for wells. Where the volume of overburden is small compared to the volume of coal removed, a depression will remain that may fill with water, forming a reservoir or lake.

During mining, water levels will be lowered in the vicinity of the mines. Water levels would also be lowered by pumping for incidental plant requirements or pumping of large quantities of ground water for either primary or supplemental supplies for steam generators, coal gasification plants, or slurry pipelines.

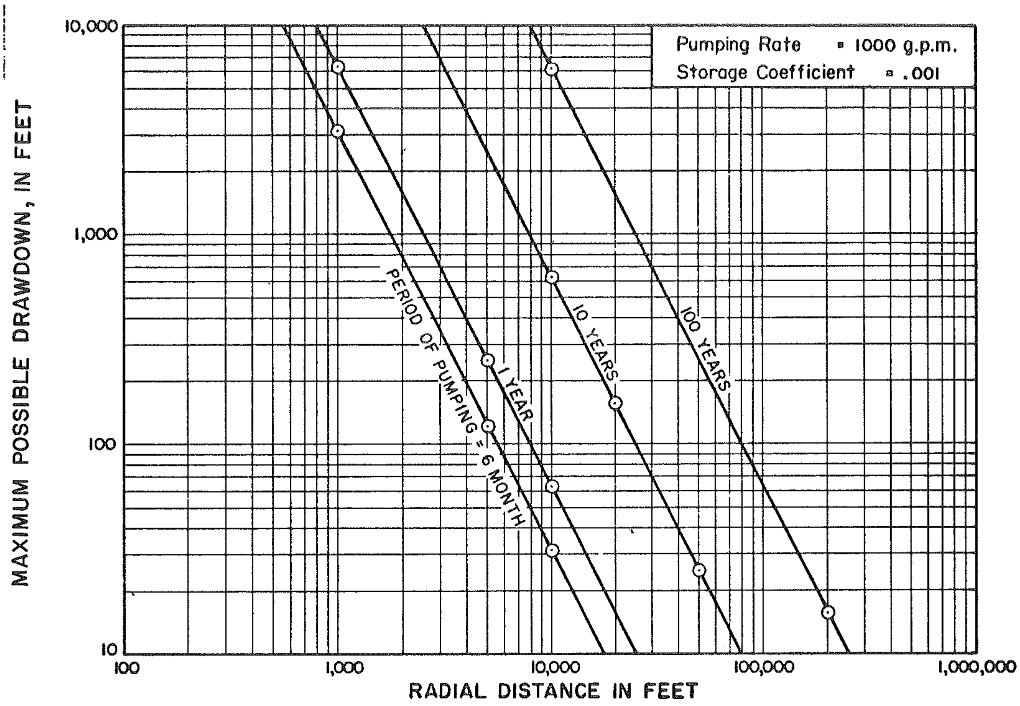
The areal extent of water level lowering will be dependent on aquifer geometry, aquifer properties, rate of pumping, and the length of time pumping occurs. The aquifer geometry may be the dominant factor determing the amount

that water levels are lowered when an aquifer is intersected by mining. Because of the presence of interbedded shale, water in many of the aquifers will be perched, and therefore, the base of the aquifer and not the bottom of the mine will be the discharge point to which the new water level gradient adjusts.

The effects of pumping from the Wasatch and Fort Union would differ, depending on rate and time of pumping, but otherwise would be analogous to the effects of pumping from the well field in the Town of Gillette. The water level in an observation well within a mile of the well field showed no decline that could be attributed to pumping of the field from the late 1940s to the late 1960s (Figure 20, Chapter IV). In the last two or three years, however, there has been a decline which can be related to increased pumping from the well field.

Effects of pumping from the Fox Hills Sandstone, Lance Formation, and the lower part of the Fort Union Formation in the vicinity of the mines where they occur at great depth, and from even deeper aquifers such as the Madison Limestone, will take many years to be transmitted to the outcrop areas and shallow domestic and stock wells. Figure 5 shows the maximum possible drawdown at different distances and different time periods. It was assumed that the coefficient of storage of the aquifers ranges between 0.0001, which is a reasonable estimate for a sandstone 100 feet thick, and 0.001 for a sandstone 1,000 feet thick, and that discharge is 1,000 gpm. Drawdown is directly proportional to discharge, so the drawdown at other pumping rates can be estimated from the graph.

In addition to lowering of water levels in wells, interruption and dewatering of aquifers could affect water levels in wells, discharge of springs and seeps, and flow of streams in the vicinity of mines.



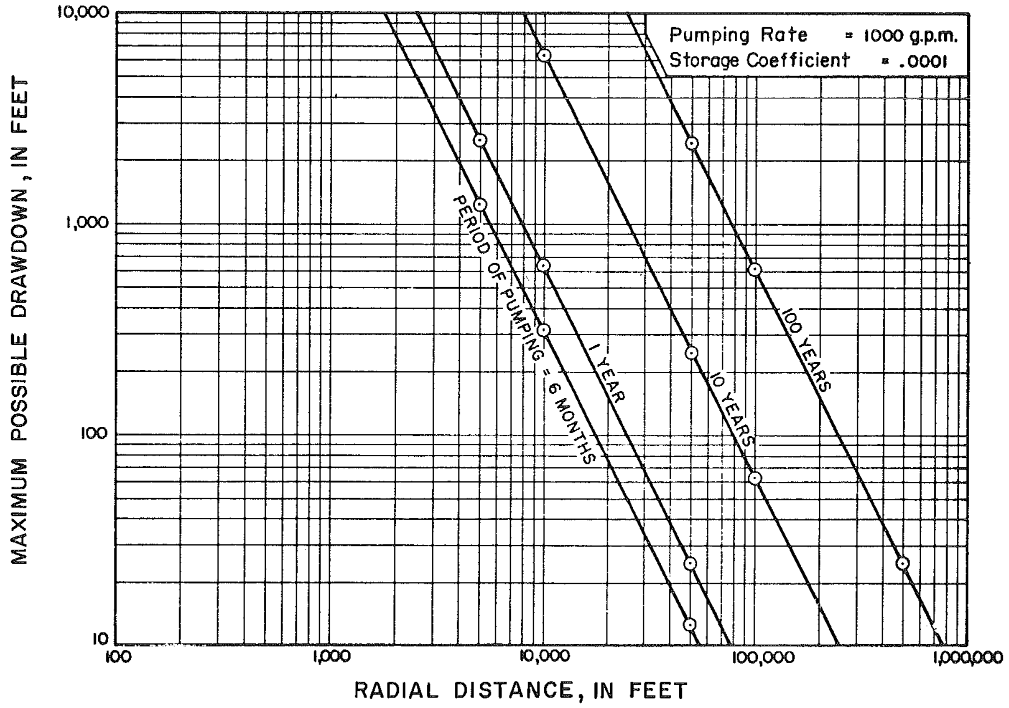


Figure 5

Maximum Possible Drawdown for a Given Distance and Time.

Coal mining near streams that were gaining water from ground water discharge during premining conditions would cause a reversal of ground water gradient. The gradient could be changed due to dewatering at the mine, and water could move toward the mine instead of toward the stream. If a good hydraulic connection exists between water in the stream and the underlying aquifer, downstream flow could be decreased because of mine dewatering. A reduction in streamflow could have a serious impact on aquatic life and vegetation dependent on that streamflow. However, there are no naturally perennial streams in the vicinity of the proposed mines. Another result of lower ground water levels would be the necessity of owners of wells to drill deeper to obtain water, which would be an economic impact.

Mine pits will be discharge points for all intercepted aquifers and there will be little opportunity for flow between aquifers until the area has been reclaimed. Some water could flow upward to the mine from deeper aquifers.

Mining operations will also alter the ground water recharge and discharge relationship. Edges of aquifers exposed in proposed mining areas are discharge points for ground water moving laterally. Mining would concentrate this discharge by changing the slope of the water table. In the event of flash floods, a mine could become partly filled with water, reversing the water table gradient, and the aquifer would be recharged for a time. However, subsequent dewatering of the mine to resume operation would again reverse the gradient so that the water which was recharged to the aquifer would be removed. The time required to remove the recharge from the aquifer would be of the same order of magnitude as the length of time recharge occurred.

Water pumped from storage in an aquifer is derived from three sources: 1) expansion of the water, 2) compression of the aquifer, and 3) compression

of adjacent and included clay beds. In areas of intensive ground water development where the artesian head is drawn down several hundred feet in aquifer systems with many clay interbeds, subsidence of the land surface can occur.

The shale that is interbedded with the sandstone and coal of the lower Tertiary and Upper Cretaceous aquifer system in the Powder River Basin will not yield nearly as much water by compression as might be expected of clay. Because the aquifer system is thick and shale constitutes nearly 50 percent of the formations, at least minor land subsidence must be considered as a possible effect of large withdrawals of water from the system.

Impacts after reclamation

After an area is reclaimed by partly or completely backfilling the mined area, there will be an opportunity for exchange of water between aquifers where the water level is sufficiently high and the area is not a discharge point. Flow between aquifers would locally decrease the head differences that occurred before mining, but the change would probably be insignificant when considering the total aquifer system.

Pre-existing recharge and discharge conditions in a mined area will not be restored by reclamation because of the disruption of aquifers. Where depressions remain below the water table, discharge will be greater than existed before mining, but where the depression remains above the water table, recharge will be enhanced.

The backfill may have higher porosity than the original material; however, permeability will be decreased because the backfill will be more heterogeneous than the original material. Where this material occurs in a discharge area, flow paths will diverge around the mined area or, possibly, some mounding and increased discharge will occur in the mined area. Where

local recharge occurred before mining, destruction of existing drainage patterns may, for a time, increase recharge by ponding water in the fill area. As drainage is reestablished, recharge will be less because of the lower permeability.

Surface flows

Impacts during mining and reclamation

Use of unappropriated surface water flows for coal development and associated uses would have varying environmental impacts. In order to assure a firm supply and to utilize the available surface water, construction of storage facilities would be necessary. Available surface water is limited in amount. Municipal and industrial water users will probably attempt to assure firm water supplies by buying or constructing storage capacity to meet their anticipated needs. Continued shortage will most likely be sustained by agricultural water users who cannot economically afford to provide the additional storage necessary to eliminate shortages in their supplies.

Construction of storage and diversion works will have increased impact on fisheries, recreation resources, agriculture land use, and aesthetics. Table 26, Chapter IV, lists applications for the larger reservoirs that have been filed with the Wyoming State Engineer. Many of the sites could provide greater storage capacity than indicated on the applications. Panhandle Eastern has already indicated that it has applied for purchase and change in use of North Platte River water. It also proposes to construct a 800-surface-acre, 24,000 acre-feet capacity reservoir on Soldier Creek near Douglas to supply water to its gasification plant.

Importation of water would affect the source area as well as northeastern Wyoming. Due to existing compact agreements and available supplies,

importation appears to be most likely from the Green River Basin. Development of this plan would have impacts in southwestern Wyoming where a reservoir would probably have to be constructed. Also, the quality of water in the lower Colorado River Basin is deteriorating and transbasin diversion of Green River water would cause further deterioration of quality.

Mining will also have direct impact on streamflow characteristics. The annual and low flows of the streams would be increased by the release of water pumped from the mines or by release of waste water from industrial plants. Peak flows would not be affected except in the small tributaries draining the developments. As open pit mines are most feasible where there is shallow overburden, the mines will generally be located within valleys, and the existing stream pattern of the site will be interrupted. Mining will cause alteration of various stream channels such as North Rawhide, Donkey, Little Thunder, and North Prong Creeks. These alterations could cause significant general and local effects on the geomorphology and hydraulics of the area's stream systems. Construction areas are highly susceptible to erosion. Introduction of large sediments into a stream may cause local aggradation which would steepen the channel and increase flow velocities, thereby causing instability of the stream at that site. Secondly, channelization may change the base level of the stream, and intervening tributaries will have to adjust to a new slope condition. As this adjustment takes place, head and down-cutting of the tributaries could result in significant erosion of the watershed. Because headcutting of channels is a condition that moves upstream, the entire watershed of an intervening tributary can be affected by the alteration of a main channel.

Impacts after reclamation

Decreased permeability of the reclaimed overburden could result in lower infiltration rates, thus annual and low flows of the interrupted streams could be increased. Also, mined areas may be reclaimed so that a lake is formed, thus peak flows as well as annual runoff may be reduced.

Water quality

Impacts during mining and reclamation

Ground water. Water quality in aquifers will not be affected, except possibly very locally, by mining of coal because movement of water in the aquifers will be toward the mine, from which it will be pumped, rather than moving away from the mine area. Where water infiltrates to aquifers through backfill deposits, some leaching of common mineral constituents, and possibly some toxic trace elements, could occur. This water will not move far, however, and will be discharged into mines or along stream drainages or as transpiration by plants. Toxic levels of trace elements could be concentrated in plants and be consumed by livestock and wildlife. This possibility needs extensive research and monitoring. Acid waters from mining are not expected because the natural water of the area generally has a pH well above 7 and because of the small amounts of pyrite and other sulphide ores present in the coal.

Surface water. The amount of dissolved solids in streams below areas of development is expected to increase during mining and reclamation. Dissolved solids in water discharged from development areas will contribute to existing stream loads. Increased dissolved solids loads in streams can be expected from runoff from newly exposed surfaces.

Change in concentration of dissolved solids in the streams will depend on the amount and concentration of water discharged and its relation

to the amount and concentration of water in the streams at the time. Evaporative concentration of dissolved solids in the mixture of water will occur as it flows downstream. Greater effects will occur during periods when a larger portion of the water in the stream is received from development areas.

Precise changes in concentrations of dissolved solids in surface water cannot be predicted at present. Further studies, including applied research and monitoring, are needed.

Discharged waste water may include petroleum products, detergents, and solvents which, if allowed to discharge directly or indirectly to the stream through settling ponds or runoff, will decrease the quality of downstream water. Data is not available to assess the impact that sewage effluent would have on stream water quality in the coal basin if the effluent were released directly to streams. However, much of the sewage effluent is likely to be treated and used for industrial supplies before final disposal.

Sediment concentrations in streamflows may be increased by runoff from disturbed areas. Disturbed areas will include spoil piles, areas denuded by construction, and channelized stream courses. Due to the relatively small areas of the disturbances, change in sediment quantity will be mainly local.

Impacts after reclamation

Ground water. During the mining of coal, ground water will be moving toward the mining area, and thus no changes in the quality of the water in nearby aquifers can be expected. In the backfill areas, however, oxidation reduction zones will be disturbed and trace elements may be dissolved after mining stops, leaching of backfill deposits is possible, and a monitoring network of observation wells in the backfill area will be

necessary to detect changes in quality of water and movement of any leached constituents in the water.

After reclamation is completed, if waste materials from power and gasification plants have not been properly disposed of, contaminants from leaching of these wastes could affect the quality of water in some aquifers.

Surface water. Changes in surface water quality after reclamation is completed will be indicative of success in the reclamation effort. Surfaces left unprotected from erosion will continue to contribute dissolved solids to streamflow at higher than normal concentration. Sediment quantity will be dependent upon erosion.

Due to evaporation and the variability of precipitation, dissolved solids in pits that may be converted to reservoirs will increase in concentration.

Water rights

Coal development could change water uses and affect agriculture and wildlife. Industrial companies have already purchased over 12,000 acres of irrigated lands with the intent of having the attached water rights changed from irrigation to industrial uses. Changes in rights will mean that less water will be available for irrigation and agricultural use. Full utilization of unappropriated water will have impacts on other resource use such as recreation, fish and wildlife, etc. These secondary impacts are discussed in other sections of this statement.

Summary

Development of coal resources in the study area will create increased demand on water resources. Demand within the study area by 1990 will increase by 50,000 acre-feet per year over present uses (Table 8).

Demand in the Powder River Structural Basin, which includes an eight-county area, will increase by 259,000 acre-feet per year by 1990 (Table 8). The total of 259,000 acre-feet includes the 50,000 acre-feet increase in demand within the primary two-county study area. Demand for the additional 209,000 acre-feet of water by 1990 will be created by coal and other related energy developments occurring outside of the study area.

Permission to test deep aquifers to determine the feasibility of removal from Wyoming of up to 20,000 acre-feet of ground water per year from the Madison Limestone and overlying Bell Sand has been granted to Energy Transportation Inc. for use in its proposed coal slurry pipeline. Senate Enrolled Act #10 of the 42nd Legislature of the State of Wyoming granted this right, subject to approval by the State Engineer, provided the water was obtained 2,500 feet or more below the land surface. The application of Energy Transportation Inc. has not been approved by the State Engineer.

Increased industrial use of water may limit amounts available for agricultural and irrigation uses. This limitation or reduction could adversely impact other resource uses such as recreation, farming, wildlife, and grazing.

Overall water quality may decrease. The total effect on regional quality cannot be assessed with data currently available. Monitoring systems will be necessary to determine actual impacts on water quality.

Vegetation

Vegetation will be removed by mining operations, construction of plants and housing to accommodate the increased population, pipelines to transport coal and manufactured gas out of the study area and water to the plant facilities, rail lines to haul the coal, and transmission lines to transport electrical energy necessary to operate mines and plants and to move the developed energy to other areas. It will also be partially disturbed by increased recreational use originating from the larger population within and adjacent to the study area.

The impact on vegetation will start prior to actual mining operations. By 1980 an estimated 8,900 acres will have been disturbed. Approximately 54 percent of this vegetation (4,800 acres) will be permanently removed by construction of plant and mine facilities, particularly the gasification plant which requires an estimated 1,000 acres. Disturbance increases during the 1980 to 1985 time period as an additional 10,900 acres are disturbed with 28 percent (3,100 acres) permanently denuded. The impact lessens during the period between 1985 and 1990 when only 9,200 additional acres are denuded with 17 percent (1,600 acres) being permanently lost to vegetative growth. The total cumulative acreage disturbed by type is shown in Table 10. Since mining operations and locations are not known with any degree of certainty beyond 1980, an extrapolation was used to develop acreages by type beyond that date. Since location of mine operations is fairly well known up to 1980, the disturbance by type was calculated with a fair degree of accuracy.

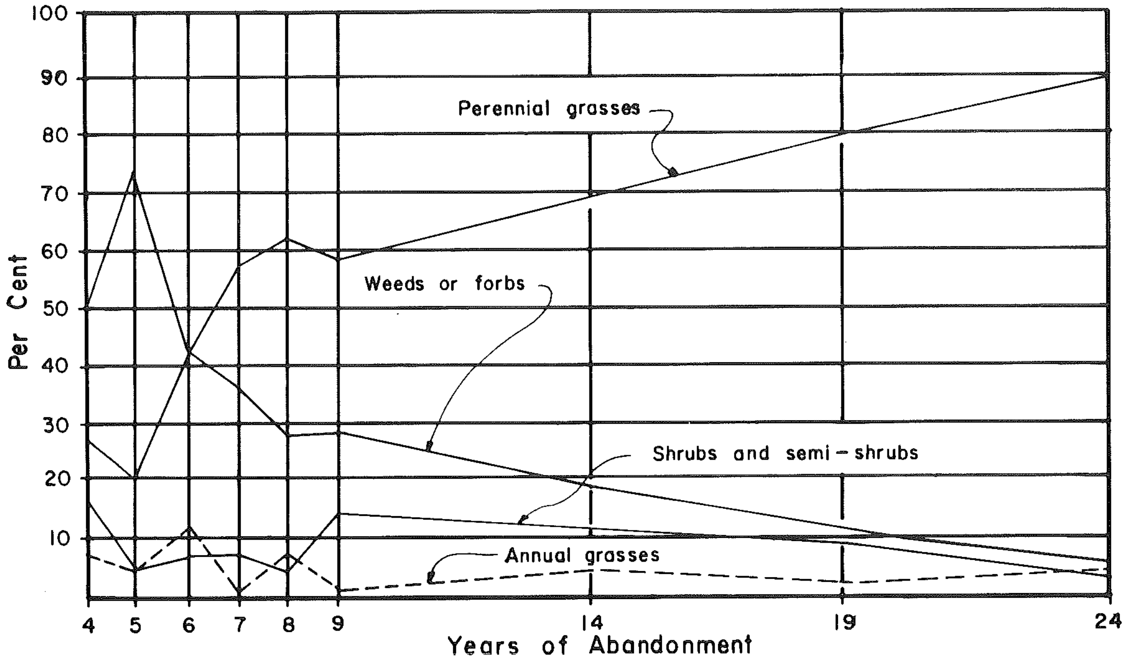
Table 10

Cumulative Disturbed Vegetative Type Acres

	Acres by Type							
Year	Dry Grass-land	Scoria Grass-land	Wet Meadow	Big Sage-brush	Grease-wood	Ponder-osa Pine	Broad-leaf Forest	Total
1980	24	315	128	8,211	80	82	42	8,90
1985	53	702	285	18,289	178	183	94	19,80
1990	78	1,026	417	26,751	260	267	137	29,00

After the initial five-year period at each mine, it is assumed that acreage disturbed by mining each year will equal the amount reclaimed as described in Chapter III of this Part. The acreage lost to construction of permanent facilities will be a long term impact. The acreage disturbed, permanently lost, and reclaimed up to 1990 is shown graphically in Chapter II.

Present plant succession will cease on all areas disturbed. Vegetation on disturbed acreage will be set back to a colonizing stage if reclamation procedures are not successful. Since mine areas represent severe disturbance and complete alteration of soil types, prediction of succession is sketchy at the utmost. The results of several studies of succession on abandoned farmlands in the sagebrush grasslands of the study area, lands which have not undergone the same type of upheavel as the mined area, will indicate that revegetation of disturbed lands to approximately original conditions can be expected to take over 50 years if left to natural succession (Lang 1941). Plant succession and percent of density on abandoned farmlands is shown graphically in Figure 6. The plant community after



Source: Lee Lang, "Some Vegetative Changes During Natural Succession on Abandoned Farm Land in Eastern Wyoming (Masters Thesis, University of Wyoming 1941), p.30.

Figure 6

Per Cent of the Total Density in the Vegetative Groups on Abandoned Farm Lands Subject to Natural Succession in Converse County, Wyoming in 1940.

reclamation may differ drastically from that present in the area now. The major component which will be missing in the reestablished community will be sagebrush.

Industrial fumes and dust from exposed coal, coal processing, roads, railroad hauling of coal, and loading operations will be deposited on vegetation adjacent to transportation routes and mining operations. This could effect plant vigor and may be damaging to leaves, especially when deposits are moistened by dew and light rain. Dust-covered and damaged vegetation may be less palatable and possibly toxic to livestock and wildlife Plant stack emissions, especially sulfur oxides, have a potentially damaging effect on ponderosa pine. Damage from this type of pollutant has been observed but not proven. Additional research is required to adequately determine the impact on vegetation from stack emissions resulting from coal-fired generating and gasification plants. This impact could damage extensive areas of vegetation beyond that physically disturbed by and as a result of coal development operations.

Changes in microclimate will occur depending upon the type of reclamation measures used. For example, changes in landform including change in slope and aspect will alter solar radiation intensities, airflow patterns, soil and air temperatures, snow accumulation, evapotranspiration, humidity, water bodies, and drainage patterns. Changes in surface color and ground texture will change soil temperatures. Change in vegetation type, for instance brush to grass, will change soil temperature, snow accumulation, air temperatures, soil moisture relationships, windflow, and shade. Changes in microclimate may have a detrimental effect on satisfactorily reestablishing vegetation following mining.

Archeological and Paleontological Values

Two archeological sites, Glenrock and Vore Buffalo Jumps, and two archeological-historical sites, Fort Phil Kearny and Fort Reno, listed on the National Register of Historic Places may be impacted by increased population brought on by coal and related developments. These sites will not receive any direct impacts from coal development.

Since there is a distinct lack of knowledge concerning archeological and paleontological values which may be located within the development area, analysis of impacts is difficult. There is reason to believe that these values do exist in the region to some degree, and the potential for significant impacts does exist.

Construction of all facilities discussed in the introduction of this section will require surface disturbance and earth movement. Estimated disturbed area will total 29,000 acres by 1990 within the region of economically strippable coal. Part of this acreage (9,500 acres) will be occupied by facilities thereby preventing assessment or examination of the overlain archeological and paleontological values.

In addition to impacts from surface disturbances, huge volumes of earth will be dug and moved during coal mining operations. An estimated 7.2 million cubic yards of material will be excavated for 1976 coal production of 8 million tons. About 1,543.9 million cubic yards of subsurface material will be excavated by 1990. Movement of this material will destroy archeological sites which may be buried within.

Increased population and the attendant increase of recreational use will also cause potential impacts on archeological sites which have not as yet been discovered or inventoried. Recreational use, particularly

off-road vehicle use, will create additional surface disturbances which would affect these values. Rockhounds, pot hunters, and arrowhead hunters could all cause an impact on potential archeological sites.

The most threatening impact, regionally, to archeological and paleontological resources is the permanent installation of facilities, displacement of data bearing soil, and the increased incidence of vandalism that will forever prevent identification and knowledge of prehistoric man and geologic history.

All the applicant companies have described their efforts to survey archeological values, some by contract with the State Archeologist, others through nonresident archeologists or local amateurs.

No known National Register sites or potentially eligible sites will be impacted by the direct action of coal and related facility development. However, because the potential for unknown values exists within soils of the study area, it is not possible to predict that no potentially eligible sites will be found. The overall regional impact of mining and its related surface disturbance of 29,000 acres by 1990 on archeological-paleontological values may appear insignificant in relation to the total size of the study area (4.9 million acres). However, the deep surface disturbance of 1,543.9 million cubic yards of potentially valuable (from an archeological viewpoint) material may be very significant. Because of this and the fact that potential archeological and paleontological values at this depth and near the level of the coal are unknown, impacts have the potential of being very significant.

Some positive impacts could accrue from coal development. A well supervised coal digging system could uncover valuable scientific data about life forms on the plains that might never be discovered otherwise because of the cost involved in exploring to these depths.

Historical Values

No significant sites have been identified within the area of presently economically strippable coal reserves or the proposed railroad route. The Sawyer Wagon Train Fight site (SE¼, sec. 12, T47N, R72W) and some abandoned homesteads on the Kerr-McGee mine property require further evaluation to determine their significance. These two sites are in areas of potential mining within the 1980 to 1990 time span. If these areas are mined, the sites will be destroyed.

Although no known significant sites exist in areas to be disturbed, major population increases (estimated 60,000 above current levels by 1990) are expected to occur within an eight-county area. This increase could have a secondary impact on all historic sites located within a half-day drive or less from major population centers of Gillette, Douglas, Casper, Buffalo, Sheridan, Newcastle, and Lusk. Increased population will place pressures on all the region's historic sites in the form of increased vandalism and pot hunting, especially at remote, unprotected sites. This impact will be modified in each instance, according to the sensitivity of the site, in terms of current physical conditions.

Much of the projected demand for sand and gravel, pipelines and right-of-way access roads may place added impact upon natural corridors occupied by potential national historic trails such as the Oregon, Mormon, and Bozeman Trails.

Impacts on historical values were developed in a study (Western Interpretive Services 1974) prepared specifically for this environmental impact statement. According to this study, the following sites will be susceptible to damage of vandalism and pot hunters:

Catonment Reno	Portuguese Houses
Fort Reno	Powder River Crossing
Hoe Ranch	Red Cloud Agency

A second possible negative impact is the road improvement required to meet demands of a larger, more dispersed population. The following sites

are located within close proximity to existing roads and are susceptible to physical impact resulting from road widening or realignment:

Antelope Springs	Seventeen Mile State Station
Minor Bozeman Trail Sites	Suggs
Crazy Woman Crossing	

A third potential negative impact will derive from community and industrial service facilities expansion. In order to meet increased water and power requirements, new pipelines and transmission lines will be routed into the area along natural corridors from Casper to Sheridan and from Douglas to Sheridan along the base of the Bighorn Mountains. A majority of historic sites identified in this study are located within proximity to these corridors and may be physically or visually impacted by pipeline or transmission line placement. High impact will occur within topographically restricted segments of the corridor.

A positive result of increased population is increased visitation at developed historic sites which will tend to foster greater appreciation of cultural and educational values as well as increasing the input of tourist dollars into local economy. The following sites are expected to enjoy greater visitation as a secondary impact of increased population:

Devils Tower	Fort Laramie
Fort Caspar Site Group	Oregon Trail Ruts
Fort Fetterman	Register Cliff
Fort Phil Kearny	

The remaining number of historic sites identified in the regional study area inventory are located at points remote from existing corridors or projected population centers and are not expected to be affected by increases in regional population or by coal development in the Eastern Powder River Coal Basin.

A professional historian (Bob Murray of Western Interpretive Services) has reviewed the list of existing and potentially eligible National Register sites with the Wyoming Historic Preservation Officer and determined that no impact will be made by the direct action of the proposed mines or railroad. Consultations and research will be continued to determine the importance of abandoned homesteads on the Kerr-McGee lease. Information on the historical surveys conducted by applicant companies and approving agencies have been forwarded to the National Advisory Council on Historic Preservation.

The overall effect of coal development may have a positive impact on historical values. This would result from the inventory and recognition of the private and public historical sites and the awareness that a potential impact exists from expansion of coal development and related activities.

Aesthetics

Coal development and its associated facilities will create impacts on the aesthetics of the study area and, to a lesser degree, areas outside study area boundaries. Development by 1990 of 11 new mines, four power plants and two gasification plants, mining of 1.5 billion tons of coal; increase in population of 60,000 in the Powder River Basin; and construction of 24 miles of road, 225 miles of powerline, 30 miles of coal slurry pipeline, and 150 miles of rail line will impact the elements (texture, lines, color, landforms, intrusions) which collectively make up the visual resource termed aesthetics.

Powerline, railroad, road, and pipeline construction and mining of coal will affect the texture of the study area. Texture mainly consists of a particular vegetative pattern. Fills and deep cuts created by the railroad and removal of vegetation over large areas or along a linear path create a new vegetative texture. A different texture is also created by reclamation of the areas disturbed by these activities. The area is reclaimed to a different type of vegetation with a height generally lower than the surrounding vegetative types. Then, too, some of the area may resist revegetation and remain barren, adding to the impact on texture.

Linear impacts are caused by rail lines, roads, powerlines, and canals and other water diversions. These facilities create unnatural lines on the landscape. In some cases, such as powerlines, the lines created are perpendicular to the natural lines of hills, cliffs, and rivers.

The predominant soft grays, greens, and browns of the present landscape will be impacted by use of red clinker for road surfacing material. Although red clinker hills exist in northern sections of Campbell County, the color of the rail line and ballast will contrast with the predominant color scheme of nature. All revegetated areas will contrast colorwise with surrounding vegetative

and land color. Species to be planted in reclaimed areas will be mostly grass, so the end result will be vast areas or long strips of colors contrasting with the surrounding mixture of grasses, shrubs, and brush. Powerline towers painted silver will provide a stark contrast with the soft greens and browns of present vegetation. Probably the most significant impact on the existing color scheme will be caused by construction and location of multi-hued buildings, homes and mobile homes throughout the region.

Cuts and fills necessary to construct roads and railroads change existing landforms. Maintaining a one percent grade on railroads will have a greater effect by requiring cuts and fills deeper than those required for roads. These cuts and fills alter landform in a linear fashion along a fairly narrow corridor, so the impact or the magnitude of the impact is restricted. Pipelines impact landform to a lesser degree, since they are buried. The major impact on landform is caused by mining and removal of large volumes of coal (1.5 billion tons by 1990). Mining results in lowering the altitude of the land, creating a more rounded and gently sloping landform and destroying abrupt changes in angles such as cliffs and sharp breaks. Impacts on landform are discussed in more detail under topography.

Every man-made or caused facility will be an intrusion and, therefore, an impact on the present landscape. Major intrusions will be those which protrude above the general plane of the landscape. Buildings, homes, plant facilities, loading silos, powerline support towers, and pumping stations will all alter the existing aesthetic character of the study area. Holding ponds and reservoirs, creating bodies of water where none existed before, are also intrusions but will not create significant impacts.

Elements which make up aesthetics have been discussed without regard to viewpoints. People view the landscape from many different points, on the ground and from the air. The view from each place along any traveled path is different. In an area this large (4.9 million acres) it is not possible to list or describe the various scene changes or the impacts on them, so impacts on viewing will be discussed in a broad fashion.

Scenic views will be changed. Indicators of this change will be unregulated solid waste disposal and litter near plants and communities, roadside billboards, bars, neon signs, and scattered tracts of new homes outside cities and around Keyhole Reservoir. Views of distant mountains and hills will be interrupted by industrial, residential, and service facilities. Because of new vertical intrusions on the skyline, many natural geologic formations will no longer be distant sights of interest. Silos at mines near these highways will capture the view. In most cases, power transmission lines and reduced air quality, especially during windy or inversions periods, will obscure the view of the Laramie Range from Interstate 25. Also, views of the Black Hills and Rochelle Hills will be modified. With new service facilities feeding Buffalo and Sheridan, some impacts will be felt upon major highways and views of the Bighorn Mountains.

The aesthetic quality of the area may be reduced for some. Others may enjoy the view of the changes more than the existing landscape. Aesthetic quality is a subjective blending together in one's mind of the various aesthetic elements. What can be said is that the cumulative impact of thousands of new people and development of all of the facilities associated with coal development will cause a change in the aesthetics of the Eastern Powder River Coal Basin.

The overall impact will be one of gradual change from what represents the quiet, rural setting, wide open spaces, basically uninhabited to a basin busy with industry and human activity. The quiet solitude and natural peacefulness will change as the area is developed. Signs of this change are already evident. The rate of change will quicken from now until 1980. During the 1980-1990 decade the rate of change will accelerate until peak development is reached and then remain fairly stable beyond 1990.

Wildlife and Fish

Coal development and industrialization of the Eastern Powder River Coal Basin will result in a significant impact on the fish and wildlife habitat and conversely on wildlife population quantity and quality. Development of 11 new mines, two gasification plants, four power plants and mining of a cumulative amount of 1.5 billion tons of coal by 1990 will physically destroy wildlife and its habitat, and reduce overall populations. The change of the area from a quiet, rural setting to one of bustling human activity, with population increases by 1990 of 47,000 within the study area and 13,000 adjacent to the study area, will indirectly affect wildlife and its habitat, resulting in a change in species composition and numbers that would be considered undesirable by many.

By 1990 it is estimated that 9,500 acres of habitat will be permanently destroyed, long-term productivity reduced on 19,500 acres and 116,000 acres impaired by increased human utilization. In addition, there will be an estimated annual loss of 200 deer and antelope in fences which will be constructed, reduction in base population of deer by five percent (850 deer), reduction of base population of antelope by nine percent (2,700 head), potential loss of the 300 head of elk currently inhabiting the study area, (particularly 90 elk in the Rochelle Hills), and an approximate loss of 940 to 1,250 sage grouse. These losses are the ones which can be quantified with any degree of accuracy. Undetermined losses of other animals will also occur.

There is a direct cause-effect relationship involved with impacts on fish and wildlife as a result of coal development. Direct mortality is rare on big game and other types which have the ability to flee. The direct action of coal development destroys or impairs habitat. This impact on habitat then translates itself into an impact on fish and animal residents,

resulting in loss. Therefore the impact analysis starts with examining the cause and the first effect--destruction of habitat and direct wildlife mortality. Then the analysis proceeds to translate this impact into its secondary effects, those on the animal itself.

Habitat destruction and direct wildlife mortality

A wide variety of development related actions will cause impacts on wildlife, and some of these such as loss of streams, ponds, lakes, springs, wells, and particular vegetative types, are not covered by quantitative impact projections made earlier in Chapter II. Where such projections and quantitative information concerning animal numbers, densities, or crucial habitat elements are unavailable, only qualitative analysis of impacts is possible. Each wildlife species in the study area will be subject to the cumulative effects of several of the different categories of impacts caused by coal development. These include:

--Direct destruction of animals.

--Permanent destruction of habitat.

--Initial destruction of habitat followed, in time, by some degree of recovery in habitat value.

--Impairment or reduction in value of habitat near human development or activities.

--Increased introduction of hazards into the wildlife environment.

--Offsite and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.

--Improvement of habitat.

A more detailed discussion of the probable impacts of coal development on the various animal communities of the study area and evidence supporting these conclusions is presented in Appendix C.

Direct destruction of animals

A number of development operations will directly destroy wild animals, ranging from individuals to entire populations. Those actions which cause the greatest losses are those which initially excavate, bury, overturn, clear, or grade large areas of previously undisturbed terrestrial habitat. The large machinery will bury, crush and suffocate many small animals, primarily those which are not capable of moving fast enough to escape and those which retreat to burrows for protection. Any operations, including well drilling, blasting or industrial and municipal use of water, which cause dewatering of aquatic habitats will result in death to fishes, aquatic invertebrates, and amphibians in certain stages of life. This type of destruction occurs over time. During the 1974 to 1980 time period surface disturbance which could result in direct mortality will occur over an estimated 8,900 acres. This impact will accelerate during the 1980 to 1985 time period when an additional estimated 10,900 acres will be disturbed. Since projected coal development levels off after 1985, the impact of surface disturbances covers only an additional 9,200 acres from 1985 to 1990.

Habitat losses

The variety of animals in the basin is too great to permit detailed description of development and rehabilitation impacts on each species. In Table 11, representative species are grouped according to important habitat requirements, habits, or life forms. Species in each group will be similarly affected by development action and rehabilitation. These species groups are used to illustrate differences in impacts due to differences in wildlife forms

and to illustrate trends in habitat values based on comparisions of existing habitat types with those expected to develop as a result of vegetative rehabilitation efforts.

Permanent habitat loss will result from actions such as construction of plants, distribution systems, communities, airports, etc. Greatest losses can be expected in the sagebrush and grassland vegetative types since they are predominant, but aquatic and terrestrial habitat will also be lost. Almost all animal species will be subjected to some permanent habitat losses. Total permanently lost acreage, based on projections, will approximate 4,800 acres by 1980, 7,900 acres by 1985, and 9,500 acres by 1990. The animals of Groups I, II, and III in Table 11 can be expected to suffer most. Where aquatic habitats are destroyed, animals in Group VIII will be impacted most severely.

Permanent habitat loss will be most significant during the 1980 to 1985 time period when an estimated loss of 3,100 acres, or 33 percent of the total estimated habitat to be lost by 1990, occurs.

By 1990, about 19,500 acres of wildlife habitat will have been disturbed which will have some, mostly long-term, potential for recovery. It is projected that about 11,800 acres of this will have undergone rehabilitation efforts aimed at establishing a perennial grassland vegetative type. Most of the habitat disturbed will be in the sagebrush and grassland vegetative types, but significant disturbance will also occur in aquatic, riparian, and pine-juniper habitats. After the initial loss, revegetation of disturbed areas by either man-induced or natural processes will begin to restore wildlife habitat in one form or another. Following initial attempts to rehabilitate disturbed areas to perennial grasslands, the majority

Table 11

Animal Species Representative of the Study Area, Listed According to Similarities in Habitat Requirements, Habits, or Life Form

Group I	In the study area, these animals are heavily dependant upon sagebrush for food or cover or nesting sites or combination thereof and/or other upland shrubs such as greasewood saltbush and rabbitbrush, especially for winter feed.	Pronghorn Antelope Mule Deer White-tailed Deer Sagebrush Vole Deer Mouse Least Chipmunk White-tailed Prairie Dog White-tailed Jack Rabbit Black-tailed Jack Rabbit Mountain Cottontail Desert Cottontail Sage Grouse Sharptail Grouse Sage Sparrow Dickcissel Lark Sparrow Brewer's Sparrow Sage Thrasher Lazuli Bunting Green-tailed Towhee Flycatcher,spp. Sagebrush Lizard
Group II	In the study area, these animals feed heavily on seeds and/or foliage or roots of weedy species of forb or annual grasses and/or nest on ground in open grasslands.	Thirteen-lined Ground Squirrel Richardson's Ground Squirrel Northern Pocket Gopher Wyoming Pocket Mouse Hispid Pocket Mouse Ord's Kangaroo Rat Western Harvest Mouse Plains Harvest Mouse Hungarian Partridge Mourning Dove Lark Bunting Savannah Sparrow Grasshopper Sparrow Vesper Sparrow Horned Lark
Group III	In the study area, these animals nest on the ground in open grasslands and/or feed primarily on perennial grass seeds or foliage.	Black-tailed Prairie Dog Prairie Vole Chestnut Collared Longspur McCown's Longspur
Group IV	In the study area, these animals depend primarily on the riparian (stream-side) plant associations and/or marshy or moist meadow areas around lakes or ponds to directly or indirectly provide food or cover or nesting or breeding sites or combinations thereof.	Raccoon Mink Striped Skunk Beaver Muskrat Long-tailed Vole Black-billed Magpie Red-shafted Flicker Wilson's Snipe Eastern Kingbird Traill's Flycatcher Goldfinch Catbird Long-billed Marsh Wren Brown Thrasher Robin Yellow Warbler Yellowthroat Long-tailed Chat Brown-headed Cowbird Western Hognose Snake Eastern Yellow-bellied Racer Common Garter Snake Plains Garter Snake Western Terrestrial Garter Snake
Group V	In the study area, these animals require the open pine timber, juniper breaks or rough, rocky topography for cover or food or nesting sites or a combination thereof.	Elk Bushytail Wood Rat Porcupine Pygmy Nuthatch Cassins Kingbird White-winged Junco Pinon Jay
Group VI	The composition of insect and spider populations and the relative abundance of different taxonomic groups vary with season, vegetative type and stage of succession. There is generally a greater variety of species and a greater abundance of individuals in the intermediate stages of grassland succession than in either the early or climax stages. Invertebrates are one of the three major groups of grazing animals.	Invertebrates, . . . including a wide variety of insect families and spiders such as: Springtails Long-horned Grasshoppers Short-horned Grasshoppers Barklice Thrips Plant Bugs Lace Bugs Seed Bugs Leafhoppers Aphids Ground Beetles Carrion Beetles Dermestid Beetles Darkling Beetles Snout Beetles Moths Midges Mosquitoes Wasps Ants Havestmen Wolf Spiders Orb Weaver Spiders etc., etc.
Group VII	These animals are all highly insectivorous, if not totally so; their presence, density, and distribution is significantly influenced by the status of local insect populations.	Hoary Bat Big Brown Bat Little Brown Bat Vagrant Shrew Masked Shrew Grasshopper Mouse Common Nighthawk Western Kingbird Say's Phoebe Bank Swallow Rough-winged Swallow Eastern Bluebird Mountain Bluebird Loggerhead Shrike Bobolink Meadowlark Eastern Short-horned Lizard
Group VIII	Members of these animal groups found within the study area exhibit from high to total dependence upon stream, lake, or pond-marsh biotic communities for continued existence.	Waterfowl, Shorebirds, Amphibians, and Fish - Grebes Herons Geese Dabbling Ducks Diving Ducks Sandpipers Snipe Avocets Phalaropes Salamanders Frogs Toads Turtles Trouts Minnows Suckers Catfishes Sunfishes Perches
Group IX	These animals are somewhat wide-ranging and/or highly flexible predators. They prey, to varying extents, on members of most other groups. Their presence, abundance, and distribution are influenced primarily by availability of prey species; in some, it is strongly influenced by the availability of nesting trees, den sites, or burrows.	Coyote Red Fox Gray Fox Bobcat Long-tailed Weasel Black-footed Ferret Badger Great Horned Owl Burrowing Owl Long-eared Owl Short-eared Owl Cooper's Hawk Red-tailed Hawk Swainson's Hawk Rough-legged Hawk Ferruginous Hawk Bald Eagle Golden Eagle Marsh Hawk Prairie Falcon Sparrow Hawk Milksnake Bullsnake Prairie Rattlesnake

of the lands will most likely receive little or no special management consideration and will be subject to the same general conditions of climate, grazing, and land use as other rangelands in the region. Where artificial revegetation fails, natural plant succession will take over.

After analysis of the available data and considering failure-success reclamation probabilities, several general observations concerning the nature of the vegetative cover which will be established on disturbed lands between now and 1990 are:

--The total vegetative cover will be greatly reduced, probably near 50 percent of that found on adjacent undisturbed range.

--The shrub component will be absent or nearly so.

--There is a good possibility that reestablished plant communities will deteriorate rather than improve over time as they are exposed to periodic drought, continued grazing, etc.

--The composition trends of plant species groups will approximate those shown in Lang's graph (Figure 6). Exceptions will be, that where perennial grass establishment due to rehabilitation is fairly successful, the trend line will rise sharply in the first few years rather than later as shown and the weed or forb trend line will drop earlier.

Because of various important plant-animal interrelationships, the recovery of habitat value will approximate the recovery of the original plant community. Figure 7 presents a qualitative indication of trends in habitat value for several of the animal groups listed in Table 11. The species groupings, while flexible, are logical for the study area.

Amount of temporary disturbed habitat increases from 4,100 acres between 1974 to 1980, to 7,800 acres during the 1980 to 1985 period, and levels off to 7,600 acres between 1985 and 1990. Figure 7 can be utilized to project what the expected value of reclaimed acreage has for different wildlife species at time points beyond the initial disturbance. With the expected slow rate

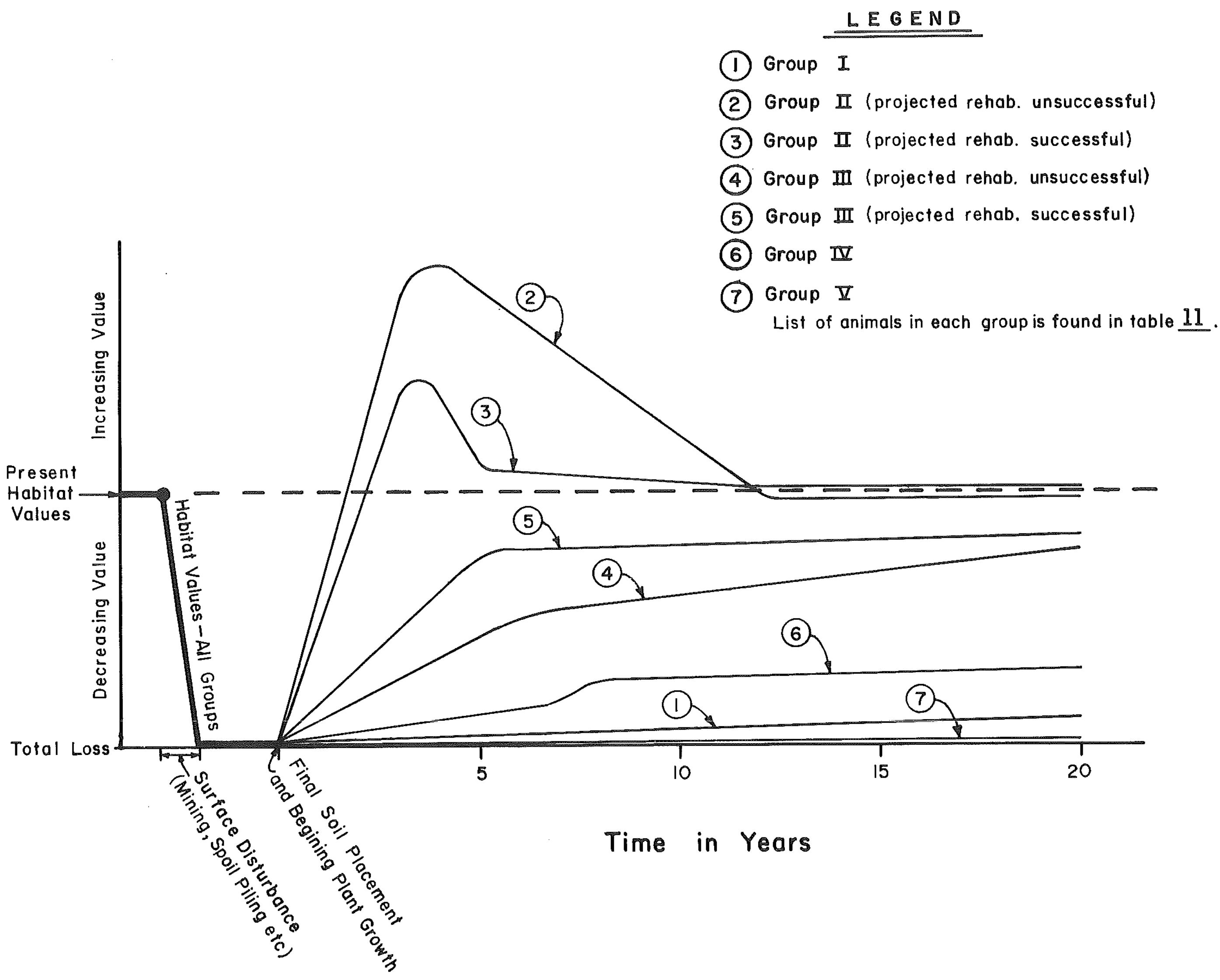


Figure 7

Expected Habitat Value Trends for Particular Animal Groups Following Attempts to Rehabilitate Severely Disturbed Lands to Perennial Grasslands.

of recovery, this habitat disturbance will most likely have a long-term cumulative impact on fish and wildlife populations and could result in losses which cannot be presently quantified.

Habitat impaired or reduced in value

The almost three-fold increase in population expected by 1990 will foster tremendous increases in human activity over the immediate study area. Humans will be living, working, and recreating in wildlife habitat never before subject to this level of intrusion. Human intrusion is tolerated only to a certain point by almost any wild animal. The degree of tolerance varies widely between species. As long as their habitat is intact, insects, for example, are relatively indifferent to human activity. Conversely, habitat of most of the larger mammals and predators will be abandoned close to areas of intense activity, i.e., around Gillette, Douglas, Buffalo, Sheridan, Newcastle, and National Grasslands. Habitat may be used only occasionally in areas near heavy, intermittent human concentration or use may be only lightly reduced with low-intensity human activity. It appears certain that the combined effects of impaired wildlife habitats will result in reduced wildlife production on an additional acreage three to five times larger than the projected 29,000 acres to be lost or reduced by 1990 through actual habitat destruction. Nearly all species will suffer, but those species of greatest interest to man, i.e., mule deer, antelope, sage grouse, will probably suffer most.

The major initial impact will occur in the 1974 to 1980 time period with population increases of 27,000 within the study area and 9,300 in adjacent areas. This impact will build from that point onward as population continues to expand and recreation use increases. The impact of this expanding population searching for recreational pursuits will significantly impair

habitat. Recreation use within the area is projected to increase from 1.4 million to 2.1 million visitor days by 1990. This use will increase the effect of coal development on fish and wildlife values.

Hazards introduced into the environment

Based on the 1970 rate of vehicle registrations per 1,000 persons, registered vehicles for Campbell and Converse Counties combined in 1990 may exceed 30,400 or a 43 percent increase over 1970. Such increased ground vehicle traffic throughout the study area will result in a proportionate increase in the level of road kills of deer, antelope, and numerous other animals.

By 1990, 150 miles of rail line are planned for construction in and near the study area. Collision hazards to various birds, small mammals, and big game species (deer and antelope) are certain to increase.

An estimated 500 to 1,000 miles of fence will be constructed around rehabilitated sites along highway, railroad, and secondary road rights-of-way and other areas. Several hundred additional deer and antelope can be expected to die in fences annually by 1990. Impacts will be compounded, especially during spring months, due to the attractive qualities of newly established grasses and forbs common on revegetated areas.

Increasing penetration, including off-road vehicle use, of presently remote or lightly traveled areas will take place. A tripled human population means that greater pressure upon coyote, bobcat, and fox populations will develop through predator calling, sport hunting, and trapping activities. Trapping takes many badger, raccoon, skunk, other mammals, and occasional birds as well. Indiscriminate shooting of animals and birds along and near roadways

will experience an upward trend even though certain species such as eagles and furbearers are protected or managed by federal and state laws.

Power demands will require construction of an estimated 225 miles of powerlines by 1990. Certain "in-flight" hazards to birds could occur. Powerlines represent an increase in the electrocution potential to large raptors.

Offsite and secondary impacts

Development of the study area will cause numerous secondary effects on wildlife through the disruption of food chains, behavior patterns, and various activities of species playing key roles in the ecosystem. Animals, especially big game, displaced from the 29,000 acres of disturbed habitat by 1990 and the much greater acreages of habitat "disturbed" by human activity will compete with resident animals for forage on adjacent ranges. While populations will ultimately be lost through natural mortality, there will be serious long-term reduction in carrying capacity of critical habitat in some areas. Predator-prey interaction will be disturbed, causing buildups of predators such as coyote in certain areas and switches in major prey species. Such disturbances can lead in time to increases in coyote predation on livestock and game species favored by man. Species such as the endangered black-footed ferret can be adversely affected by losses of prairie dog colonies. Prairie dog colonies are known within the area to be disturbed, but an inventory of all colonies is not available. Further adding to the problem of an inability to quantify possible impact on the black-footed ferret is the fact that a survey of the prairie dog towns to determine if they contain black-footed ferrets has not been accomplished. The only positive statement of impact that can be made is that reduction of prairie dog towns reduces

the ferret's food supply, and this in turn would reduce the possibility of ferrets maintaining themselves.

Impacts upon terrestial and aquatic habitat outside the study area must also be anticipated. Industrial water requirements in the Eastern Powder River Coal Basin may increase beyond that which is available "onsite." The proposal perhaps posing the most significant effects on habitat is that of transferring water use from agricultural lands to purely industrial uses. Much of this water maintains a fish and wildlife habitat base on irrigated meadows, irrigation ditches, streams, and reservoirs.

Concern for possible offsite long-term fish and wildlife reductions or changes through habitat impacts as the result of industry water use proposals cannot be overemphasized. The extent and types of faunal effects cannot be determined at this time. The prediction would depend upon presently unavailable information, including location and size of projects.

Improvement of habitat

The broad scale development forthcoming in the study area will mean some potential for improved habitat and benefited wildlife if we keep in mind that this usually means trade-offs.

The disturbance of large land areas is expected to result in vegetative changes favoring increases in population of some rodent species. Certain predators (coyotes, red fox, and various raptors) will benefit from these increases. These improved conditions are expected to be temporary on any particular area of disturbed land.

Specific group and species impacts

The impacts described previously add up to important cumulative adverse impacts on various fish and wildlife of the study area. Significantly, the magnitude mentioned does not totally quantify potential development of many private and state coal lands, coal development after 1990, or developments already expanding in the basin related to production of uranium, oil and gas, and others. The following attempts to summarize the total impacts from federal coal lease development on specific wildlife species and groups to the extent that information is available and impacts can be quantified.

Threatened species

Ten species (black-footed ferret, spotted bat, prairie falcon, American peregrine falcon, northern swift fox, ferrunginous hawk, prairie pigeon hawk, mountain plover, northern long-billed curlew, western burrowing owl) having threatened--including endangered--or undetermined population status are known or believed to occur in the Eastern Powder River Coal Basin. An additional four species (shovelnose sturgeon, goldeye and sturgeon chub, western smooth green snake) that have been identified by the Wyoming Game and Fish Department as being rare or endangered within the State of Wyoming may occur in the study area.

Inventories as to the exact occurrence and dependency of these species on the area to be developed and/or disturbed have not been accomplished. Therefore, precise impacts cannot be analyzed at this time. Habitat which is suitable for use of these species is found in the area. Unless certain species inhabit the area to be disturbed, where direct mortality could occur, the major impact would be a reduction of the range of habitat which is suitable for their continued existence. Without adequate knowledge of ranges and habitat requirements, any reduction in range may have serious long-term consequences.

Big game

Deer. Nearly 17,000 deer directly or indirectly depend on the study area for survival. Key deer habitat types, about 1,300,000 acres, occur in moderately timbered areas, rough breaks, and along drainage courses. Total deer habitat in the study area includes over 4,500,000 acres (Map 10, Appendix A). Deer, which are presently at or near maximum populations in balance with available habitat, will be displaced from parts of these areas and forced to compete with deer on adjacent lands. Deer numbers are determined by numerous factors which include the availability of food near suitable protective cover. The removal of existing browse plants through coal development activities will result in significant local reductions of deer.

No satisfactory evidence is presently available which would suggest that strip mined areas can be satisfactorily revegetated with plant communities that will satisfy the needs of deer. Therefore 50 percent of the total area disturbed by 1990 (14,500 acres) will be lost as deer habitat.

Human population growth and more intensive associated activities will further shrink the amount of favorable deer habitat. The combined effects of new human access to relatively undisturbed habitat, increased stress and competition for space (homes, service facilities), hazards (roads, increased hunting, fences, railroads), and other habitat loss may be expected to result in an estimated five percent reduction (or 850 deer) in the base deer population by 1990.

Antelope. Habitat (seasonal and year-long) is currently provided for about 30,300 antelope. Over 8,000 are harvested annually through sport hunting in and near the study area (Table 28 and Figure 63, Chapter IV). About 29,000 acres of antelope habitat, of which about 68 percent (19,700

acres) is winter range, will be physically lost from permanent disturbance and failure to properly rehabilitate by 1990.

Impacts described previously for deer mainly apply to pronghorns as well. Hazards such as fencing are particularly damaging to antelope, especially during periods of stress. In addition, successful reclamation efforts which result in simple grassland vegetation will not be sufficient for antelope.

Federal coal development in the study area will result in an estimated reduction in excess of nine percent (2,700 or more antelope) of the base antelope herd by 1990.

Elk. Coal development will deny elk a higher percentage of their habitat than other big game species. This is due to their greater inability to tolerate noise, activity, and human presence in areas of marginal cover. This fact alone will probably lead to the virtual disappearance of over 300 head of elk from the study area as population expands.

Fish

When mining or related operations involve the elimination or drastic modification of existing streams, ponds or reservoirs, direct habitat loss will result. It is not possible to project specifically how much "total" habitat loss will occur. Much of the fish habitat in the study area is already marginal due to intermittent, unpredictable, or very low flows and high water temperatures.

Annual and low flow of streams will sometimes be increased by the release of production water. Such "waste water" may include petroleum products, detergents, and solvents which, if allowed to discharge into streams, will decrease the quality of downstream water and interfere with or halt vital functions of fish populations.

The amount and concentration of dissolved solids in streams below areas of development will increase during mining and reclamation. This will result through runoff from disturbed areas such as spoil piles, denuded areas, and channelized stream courses. Both wind and water erosion will introduce sediment. Where resulting turbidity and siltation exceed tolerable levels, lowered biological productivity will result.

Water requirements for power plants and gasification and slurry pipelines will increase steadily through 1990. When large storage reservoirs are constructed, new fishery possibilities will be present if water quality is adequate. Stocking and other concerted management efforts may provide significant fish habitat at such sites.

Upland game birds

Sage grouse. Destruction and impairment of habitat, and in particular sagebrush grassland, will result in the loss of five to eight birds per square mile of habitat. An estimated three to four percent (940 to 1,250 birds) of the base sage grouse population in the study area will be lost due to coal development by 1990.

Sharp-tailed grouse. Good quality grassland and brushy cover requirements, coupled with nonmigratory behavioral tendencies, characterize this species. Habitat removal or severe disturbance will result in a direct and permanent loss of sharp-tails. Total population numbers are unknown so actual loss cannot be quantified.

Hungarian and chukar partridge. Populations are low in the study area. By further reducing available habitat, population declines will occur. Population inventories are unavailable. Therefore impact cannot be determined at this time.

Merriam's turkey. Turkeys represent a peripheral species in the study area. Their habitats of mountain forests and broken woodlands, characterized by ponderosa pine, fall generally outside of potential impact areas. Overall impacts to turkey populations are expected to be slight.

Mourning dove. The seed eating and migratory dove is highly adaptable to a wide variety of habitats. Insufficient information is presently available to fully analyze impacts upon the species. Preliminary investigations in the study area indicate the mourning dove to be a common species which seasonally depends heavily on grasslands and open ground for foraging. Dove experienced population increases in 1972 and 1974, declines between 1978 and 1970, reasonably static levels until 1972 and finally sharply increases by 1974. These preliminary results are based on three routes run in the general study area of northeastern Wyoming.

Waterfowl

The change or elimination of ponds, streams, and reservoirs will create an adverse impact upon waterfowl, especially ducks. Although dependent upon surface waters, the range of waterfowl extends beyond aquatic and riparian habitat located in the study area. Forced to move to other areas, waterfowl will be required to compete for suitable habitat. Where such resources are already utilized, overall waterfowl populations will be reduced. It is known that thousands of small reservoirs and permanent ponds in intermittent stream sections produce ducks. Brood production will be lost in those areas at an estimated rate of two to four ducks per surface acre of aquatic habitat disturbed or destroyed. Based only upon known aquatic habitat areas where losses appear likely, an estimated annual loss of 400 to 800 ducks can be expected. However, at the completion of mining, where overburden is not sufficient to completely reclaim the final pit, new water bodies may be created which would have a beneficial impact on waterfowl.

Other birds

All raptorial species, but particularly the eagles and peregrine and prairie falcons, are intolerant of human activity and habitat disturbance. Displacement of raptors will create territorial competition for adjacent habitat.

Human caused mortalities, such as shooting and collisions with autos, will increase.

Shore and song birds will be displaced and forced to seek new habitat areas. Since population levels are determined by the availability of suitable habitat, some will succumb to natural mortality.

Other mammals

Predators and furbearers. The availability and abundance of suitable prey species generally control the condition and level of predator populations. With destruction of insect, rodent, small mammal, and aquatic life, most predator populations will also suffer.

Predators such as coyotes, bobcats, and foxes will realize less immediate population impacts because of their wide ranging nature and flexible feeding habits. The badger has low ability to relocate and adapt to shrinking habitat conditions. Species such as the skunk and raccoon, closely tied to stream courses and riparian habitat, will experience population decline with habitat damage or removal.

Furbearers, including mink, beaver, and muskrat, will be extremely susceptible to habitat disturbance. The loss of aquatic habitat in association with riparian vegetation will drastically reduce, if not eliminate, these animals.

Rabbits and hares. This group consumes considerable amounts of grasses, shrubs, and other herbaceous material. Forced removal from home territories will result in intraspecific (among their own kind) competition. Using cottontail and jackrabbit densities indicated in limited studies, by 1990 cottontail and jackrabbit population of about 148 and 101 per square mile, respectively, will be lost on 28 square miles (estimated 7,000 rabbits)

and lost with only slight recovery on 19 more square miles which would involve approximately 4,700 rabbits.

Rodents, bats, and shrews. Substantial losses of small mammals will occur during mine operations in areas cleared for stripping, equipment work areas, etc. The existing fauna will likely succumb or move to adjacent areas where temporary, abnormally high densities might result. Mortality rates then would increase until population densities were again stabilized.

Rodents generally exhibit high reproductive rates which will likely allow rapid recolonization of successfully reclaimed lands.

Bats and shrews are largely insectivorous. Habitat removal will eliminate shrews while bats would possibly be able to effectively relocate themselves. The potential impacts to existing bat populations are not clear.

Invertebrates

Existing populations are diverse, numerous, and important for their positions in food chains. The majority of species present are herbivores. Permanent loss of vegetation through mining and construction of facilities will result in direct loss of invertebrates. The role of different invertebrates in a reclamation habitat may either be favorable as a result of insect-plant or insect-other-animal interactions, or undesirable as a result of one or more species becoming pests on vegetation in reclaimed areas.

Environmental damage followed by reclamation efforts will result in reduced invertebrate populations and changed species compositions. Population densities and diversities will be dependent upon the degree of reclamation success and the range of variation or tolerance ranges offered by "new habitat" produced.

Reptiles and amphibians

Available information is not sufficient to allow a complete analysis of impacts.

Species known or suspected to occur in the study area fall roughly into two categories--those which are intimately tied to surface water and those whose needs are chiefly terrestrial in nature. Most reptiles and amphibians do not readily migrate from disturbed areas. While the tolerance range of reptiles and amphibians is quite wide, elimination or drastic modification of surface water or terrestrial habitat will result in direct population losses.

Recreation

Major impacts on recreation use will result from loss of land base (8,900 acres by 1980, 19,800 acres by 1985, and 29,000 acres by 1990); increased population within the region (37,000 by 1980, 53,000 by 1985, and 60,000 by 1990; and change in water use and increased industrial and municipal consumption of water in the study area (27,600 acre-feet per year by 1980, 43,100 acre-feet per year by 1985, and 49,600 acre-feet per year by 1990). The impact will begin prior to opening of new mines and will become significant during the 1980 to 1985 interval, and level off thereafter.

The total area of Campbell and Converse Counties is approximately 5.7 million acres of which 700,000 acres are federal land and 460,000 acres are state land. Most of the federal and state land is in scattered tracts; however, the National Grasslands with 31,600 recreation visitor days in 1973 (344,000 acres) is the largest area of fairly well blocked federal land. The remaining federal land (385,000 acres) is scattered as small isolated tracts.

Therefore, any reduction in the recreation land base, although not significant when compared to total land base, may be extremely significant in comparison to the area available for this type of use.

The major recreation use in the study area today is hunting. Loss of approximately 29,000 acres of land by 1990 will reduce game populations (850 deer and 2,700 antelope). Hunting restrictions such as smaller hunt areas and shorter seasons will increase in order to provide maximum recreation opportunity yet maintain maximum producing big game herds. Because of population increase, resident hunting demand is expected to increase by 65,800 (66 percent) hunter days for antelope and deer over present levels by 1990. Projected increased resident hunting demands are shown in Table 12.

Table 12

Projected Increased Resident Hunting Demand

	Hunter Days*		
Animal	1980	1985	1990
Deer	22,500	32,800	37,000
Antelope	17,600	25,500	28,800
Total Increase	40,100	58,300	65,800

*Includes inside and adjacent to study area.

Industry with its attendant population increase will require additional acreage. Development of material sites, replacement agriculture lands, and increased recreational use, such as off-road vehicle use, will alter additional recreational land. As experienced in other states, when population and recreational use levels increase, more private land normally available for this type of use is closed and posted, further reducing the recreation land base. Residents have been very reluctant to pay hunting fees to landownders and rapid, rather significant, changes will have to take place in the attitudes of landowners and hunters if sufficient harvests are to be obtained. The loss resulting from this type of action could be more significant than the physical loss of land base to coal mining and its required permanent facilities. In all probability by 1985 the hunter will leave the study area to pursue his recreation in the adjacent mountains and plains. Hunting quality within the Eastern Powder River Coal Basin is not expected to return to its present level as commitment to development of the basin's coal energy mineral resources will have a long-term impact on wildlife populations and habitat.

Though limited in the basic study area, water-oriented recreation use does occur outside the region being analyzed. Coal development and associated activities will consume large amounts of water and decrease water quality. Wyoming statutes provide for a change of water right to higher, preferred uses, with industry use rated higher than agriculture. Agricultural water maintains a recreation base on irrigated meadows, ditches, fishing streams, and reservoirs which provide for an indeterminate amount of recreation use by fisherman, sightseer, hiker, and general outdoor user. If commitments of water involving the major mountain water courses are made to industry, these water losses will result in reduced water-based recreation opportunities and use. This water loss problem is clearly illustrated by Keyhole Reservoir which is presently being administered for recreation as a state park, yet approximately ninety percent of the water is sold to South Dakota. If this water were used, the state park would be destroyed and one of the major water-base recreation facilities in the study area would be lost.

Reduced water quality resulting from overutilization of sewage plants and solid waste from mine and conversion facilities (gasification and power plants), increased sedimentation as a result of accelerated erosion, and gravel mining in streams will affect fishing, swimming, and other associated recreational uses. This impact will be most noticeable offsite and downstream from the area of development along the Belle Fourche, Powder, and North Platte Rivers and reservoirs such as Keyhole and Glendo.

Much of the projected demand for sand, gravel, and clinker material (excess of 1.5 million cubic yards by 1990) may be mined from stream courses, alluvial mountain slopes, or limestone outcrops within the study area. This will impact scenic recreation lands, either directly (streambeds) or indirectly (sightseeing).

The anticipated population growth will generate increased demand on recreation facilities. Based on average per capita rates, the estimated

future recreation demand for such pursuits as hiking, picnicking, camping, etc., are shown in Table 13. Demand upon urban recreation facilities is illustrated in future projections as shown in Tables 35 and 35a, Appendix C.

Table 13

Recreation Visitor Days by Type

	1970	1990	Percent Increase
Hiking	167,649	275,565	64%
Picnicking	383,751	647,069	69%
Camping	253,809	424,789	67%
Fishing	503,663	646,632	28%
Boating	63,264	116,262	84%
Total	1,372,136	2,110,317	54%

Recreation facilities such as Little Thunder Reservoir and Little Powder River Wildlife Area in the National Grasslands and Devils Tower, Keyhole, Guernsey, and Glendo State Parks near the population centers of Gillette and Douglas (35-60 miles) will experience the greatest demand and be subjected to greater impacts.

With increased physical access, some additional federal land in the National Grasslands may become accessible for recreational use. This would offset some of the other losses in the recreation land base but also put additional pressure on wildlife needed for regional recreation.

Development of coal mines, power plants, gasification plants, railroads, and access roads will have a positive impact on recreational sightseeing. These facilities will provide interesting and educational viewing for the visitor, provided interpretive facilities are furnished.

Reduction in air quality from coal development and industrialization will impact the recreational sightseer. During inversion periods

and high winds, visibility will be reduced, obscuring the scenic views of the area and reducing the visitor's enjoyment. Additional powerlines will also impact the sightseer and reduce his enjoyment of the view.

Recreation quality is a subjective value judgment. The open, uncluttered, sparsely inhabited characteristics of the study area will change. To those who value solitude, this change will represent a loss. To those more gregarious, the change in type of recreational atmosphere will be a positive impact.

Selection of reservoir sites may have positive benefits for recreation (if reserves are dedicated); however, the sites may displace some of the few remaining stream fisheries. Rocky canyons and mountain meadows along streams provide excellent sources of food for fish and big game and if inundated will effect the remaining stream course below the dam.

The overall effect of coal mining on the recreation resource of the study area will be to diminish present quality for the residents. It may also affect long-term economic strength for certain business sectors by reducing nonresident recreation days. Increased use of recreation resources outside the study area could result in the lowering of recreation quality in an ever widening circle.

Agriculture

Development of Eastern Powder River Coal Basin coal reserves, on-site utilization and transportation within and out of the study area, will lead to changes in land use. These changes will ultimately be at the expense of existing agricultural lands since agriculture use is the dominant land use on approximately 94 percent (4,600,000 acres) of the study area.

Construction and development of the facilities described in the introductory part of this impact section will result in land use changes on approximately 29,000 acres. Of this amount, 33 percent (9,500 acres) will have been permanently removed from production by construction of plant facilities, residential areas, roads, and railroads. The remaining 19,500 acres will be in some sequence of reclamation. An estimated 61 percent (11,800 acres) of the temporarily disturbed area will have been reclaimed by 1990.

Approximately 0.6 percent of agricultural land will be disturbed and lost to production by 1990. The permanent loss will amount to only 0.2 percent of the total available agricultural land. The permanent loss is not a significant regional loss, but it may be quite significant to the rancher experiencing the loss. However, in most cases he is compensated through purchase of his land by the mining company.

Livestock grazing

It is anticipated that 35 percent of all coal development will take place in the vicinity of Gillette and northward, where a loss of 4.3 acres would represent the loss of one animal unit month of grazing (AUM). The major portion of the coal development is projected to take place between Gillette and Douglas in an area where each animal unit month of grazing is

assumed to average 6.5 acres. Based on these assumptions and an estimated 96 percent of the agricultural lands being used for livestock grazing, a summary of the projected annual loss of AUMs is shown in Table 14. At the assumed rate of development, the projected cumulative annual loss of livestock forage would be 1,515 AUMs by 1980, which increases to 3,435 AUMs by 1985 and 5,067 AUMs by 1990. Compared to an estimated total of 831,923 AUMs of average annual livestock forage available within the study area, this represents approximately 0.6 percent loss of the annual forage base by 1990.

Besides direct loss of livestock forage, secondary impacts associated with population increases due to construction, mining, and related developments will occur. Recreation use will occur that causes a nuisance problem and may cause temporary impairment of livestock forage use. Livestock are generally left unattended on the open range most of the time with little control other than fences. Improved access and the projected increase in population will result in increased vandalism of livestock watering facilities and fences by hunters and general outdoor recreationists. Rustling and disturbance of property has occurred in the past because of the inherent lack of protection. Molestation of grazing animals, especially during calving and lambing by off-road vehicle use, is a serious problem to ranchers. These types of incidents would be expected to increase. Expanding residential areas will result in greater impact on agricultural lands and grazing livestock.

Construction of railroads, highways, and service roads will lead to land separation and alter present ownership patterns. Railroad, highway, and many county or heavily travelled access roads are usually fenced to prevent accidents and loss of livestock. This will result in the separation and isolation of ranch properties, which will disrupt established use patterns, cause

Table 14

Summary of Projected Loss of Agricultural Land and Production

Year	Total Land Area Removed From Agricultural Production (Acres)	Land Removed From Livestock Forage Production (Acres)	Annual Livestock Forage Lost* (AUMs): 15"-17" Precip-itation Zone 4.3 Acres/AUM	Annual Livestock Forage Lost* (AUMs): 10"-14" Precip-itation Zone 6.5 Acres/AUM	Total AUMs	Land Removed From Crop Production (Acres): Dryland	Land Removed From Crop Production (Acres): Irrigated**	Annual Hay Production Lost (Tons): Irrigated 1.62 Tons/Acre	Annual Hay Production Lost (Tons): Dryland .78 Tons/Acre	Total Tons	Annual Dryland Wheat Lost (Bushels) 18.6 Bushels/Acre	Other Cropland Lost (Acres): Dryland	Other Cropland Lost (Acres): Irrigated
1980	8,900	8,352	680	835	1,515	189	359	439	77	516	1,265	21	89
1985	19,800	18,936	1,541	1,894	3,435	421	443	543	173	716	2,827	46	109
1990	29,000	27,934	2,274	2,793	5,067	616	450	549	254	803	4,129	68	111

*Assumes that 35 percent of the land disturbance will occur in the 15"-17" P.Z. and 65 percent in the 10"-14" P.Z.

**Acreage assumes most irrigation land will be lost in the Douglas vicinity mainly due to urbanization with a projected 50 acres loss per 1,000 increase in population.

access problems to livestock waters, buildings and for care of livestock. Small isolated tracts could result, which are too small in size to be used profitably.

Livestock drift with the wind during extreme blizzard conditions of severe winter storms. Historically, heavy livestock losses have occurred by animals being trapped by fences, deep-cut draws and other obstacles. Many projected developments will create additional obstacles. Additional livestock losses can be expected to occur from obstacles and traps created by additional fences, road and railroad rights-of-way and similar developments.

Physical separation of adjoining private land from Bureau of Land Management federal grazing leases and division of grazing allotments by fenced rights-of-way may cause loss of leases or, in the case of Forest Service administered lands, necessitate realignment of grazing allotment boundaries and users. Some loss of grazing use on federal lands will occur due to coal developmental activities and is included within the total projected loss of agricultural land and production.

Generally, each livestock watering facility services several square miles. Some loss of livestock water is anticipated through change of land use or land severance. Increased use of ground water supplies may also result in the loss of livestock water wells by lowering water levels. The loss of water source could affect the usability of several square miles of rangeland. The high cost of replacing wells and reservoirs may prevent easy reestablishment of adequate livestock water.

Some grazing lands could be affected by increased erosion and sedimentation. Alteration of drainages by mining or disturbed lands could cause accelerated erosion and headcutting in productive drainage bottoms resulting in additional losses of livestock forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

Farming

Loss of nonirrigated farmland production is estimated on the basis of total land area occupied, compared to the total county land area. A summary of the projected loss of crop production and farmland is contained in Table 14.

It is estimated that 189 acres of nonirrigated cropland would be removed from production by 1980, 421 acres by 1985, and 616 acres by 1990. Crop production losses by 1990 would, therefore, be anticipated to be equal to 254 tons of hay and 4,129 bushels of wheat annually. This would represent 0.7 percent of the estimated average annual nonirrigated hay production of 38,625 tons and 0.8 percent of the total nonirrigated wheat production of 528,652 bushels in the study area.

Impacts to irrigated croplands is anticipated to occur due to the projected expansion of Douglas. Additional irrigated cropland may be affected by industrial water diversions and rights-of-way for roads, pipelines, railroads, and similar developments.

The anticipated loss of 450 acres of irrigated cropland would result in a loss equal to 549 tons of hay, plus yield from 111 acres of miscellaneous and minor crops. This loss of hay production would represent approximately one percent of the 48,876 tons produced annually from irrigated croplands within the study area.

Loss of productive irrigated cropland will also occur from conversion of irrigation water rights to industrial use. The possible loss of irrigated cropland due to water conversion is shown in Table 15.

Table 15

Projected Cumulative Loss of Irrigated Cropland
Due to Water Right Conversion

	Projected Annual Industrial & Municipal (Acre/Feet)	Irrigated* Cropland Lost (Acres)
1980	12,620	11,473
1985	28,120	25,564
1990	34,620	31,473

*Assuming 1.1 acre-feet of water is used per acre of cropland.

Industry has already made known purchases of 12,000 acres of irrigated cropland with the intent of water right-conversion for use within the study area by 1980. This conversion would involve an estimated 13,200 acre-feet of water. Additional purchases are presently being made throughout the Powder River Basin and the North Platte River system in Wyoming for use in coal development inside and outside of the study area. Irrigation water is the major supply available to industry although some plans are being developed to obtain water from deep wells. The anticipated use of deep well water is not contained within the projected industrial and municipal water needs as shown in Table 15.

Based on present information, water is indicated to be in short supply to many acres of irrigated croplands. Loss of water for irrigation could not be readily replaced from existing sources. Approximately six percent of the irrigation water would be needed to satisfy the projected industrial and municipal needs by 1990. This represents the loss of a source of winter feed to the livestock industry equal to 67,200 tons of hay in an area with a winter feed deficit.

Summary

The direct loss of agricultural land and production by 1990 would not constitute an important regional impact as lost production by that time is anticipated to represent one percent or less of the total regional agricultural production.

Land severence problems, loss of livestock water, and other disruptions will occur and some livestock will be lost directly to hazards created by mining, construction, and operation activities. These impacts

will be localized in nature and would not involve a major change in the region's agriculture.

A projected six percent loss of irrigation water supplies and hence irrigated cropland production would not be considered to be a significant impact to overall agriculture within the study area. Locally, this could be a significant impact. However, water conversions beyond 1990 projections may have serious impacts on total irrigated cropland production within northeastern Wyoming and on livestock operations that rely on irrigated hay production for winter feed.

Impact on individual ranchers cannot be determined on a regional basis. Loss of agricultural land could result in higher prices within the area as additional supplies and livestock feed (hay) would have to be brought into the area.

Transportation Networks

Impact on transportation networks will be caused by: (1) mining of coal and construction of utilization and transportation facilities, (2) transportation of coal out of the study area, and (3) increased employment and population with its attendant increase in vehicles and miles travelled.

The actual impacts on transportation networks resulting from population increases will be primarily on highway commuting and airports. The Gillette/Campbell County Airport will most probably receive the major impact from increased use.

Based on the 1970 rate of vehicle registrations per 1,000 persons, the projected number of registered automobiles for Campbell and Converse Counties by 1990 is 30,400. This is 43 percent more than in 1970. The highway arteries that will be most impacted are State Highway 59 between Gillette and Douglas and U.S. Highways 14 and 16 combined, north and east of Gillette. By 1980, State Highway 59 is expected to have a flow of approximately 3,300 vehicles per day north of Reno Junction and 1,000 vehicles per day south. U.S. Highways 14 and 16 north of Gillette are expected to have about 2,400 vehicles per day. U.S. 14 and 16 east of Gillette will probably receive less traffic when Highway I-90 is completed. Increase in road maintenance and vehicle accidents will result. The Wyoming State Highway Department estimates that substantial improvement and upgrading of State Highway 59 between Gillette and Douglas will be required to accommodate the projected traffic flow increases. This upgrading and improvement will create minor environmental impacts on soils, vegetation, and wildlife. Present accident rate on this stretch is 2.6 per 100 million vehicle miles of travel. The State Highway Department predicts that even if traffic flow doubles or triples the rate will not change but more accidents will occur as the number of miles travelled will increase.

Carter Oil Company intends to reroute a portion of State Highway 59 north of Gillette to a point east of the coal lease. Overall impact is viewed as beneficial in that it takes through traffic further from the mining area to avoid possible congestion with mining traffic. This road is only lightly used with less than 400 vehicles per day. A limited number of minor graded dirt roads and gravel roads lie within mining lease areas but they are generally lightly travelled and could be rerouted if necessary without much disturbance to traffic. The State Highway Department foresees no difficulty with these roads.

Construction of the primary railroad route will cross as many as 50 unimproved and graded dirt roads and many lesser roads which are all generally lightly used for access to ranches and oil fields. Grade crossings or detours will be provided during construction which will cause an inconvenience impact on the traveller. Once the railroad commences transporting coal, 46 unit trains per day by 1990 may be expected from Gillette to Douglas. Impacts on the designated highways will be negligible inasmuch as they will be crossed by an overpass and thus not impede the flow of vehicular traffic. The Wyoming State Highway Department has indicated that a potential traffic tie-up problem may develop at Glendo where the existing railroad tracks cross U.S. Highway 26 and 87 combined. The present signal and gate at this location may have to be replaced by an overpass. Unlike the crossings of the designated highways, the crossings of numerous lesser roads will be by standard grade crossings. Although these roads are less travelled, train traffic of up to 46 trains per day will restrict freedom of travel across the tracks. A potential for an inestimable number of train-auto accidents is possible.

Numerous new roads, railroads, power and pipelines are proposed for construction. The pipelines and transmission lines are depicted on Figures 82

and 83, Chapter IV. These proposals, at least during the construction phase, will impact and disrupt some existing transportation networks. Minor electric transmission lines may require relocation due to mining activity but without inconvenience to the user or cost to the owner. A similar circumstance applies to any pipelines that may require relocations. Railroad construction is not expected to affect any electric transmission lines or pipelines other than requiring some minor line relocations. The construction of the three proposed 230-kv electric transmission lines is not expected to impact existing transportation networks. Highway crossings are usually achieved with a minimum of delay.

Construction of both the slurry and synthetic gas pipelines will cross numerous unimproved and graded dirt roads with little impact other than temporary detours during construction. Highways in this vicinity are not heavily travelled and little congestion or delay is expected. No impact is expected on electric transmission lines but other pipeline routes are being crossed and caution must be exercised during construction to avert the accidental rupture of an existing line.

A new highway is proposed for construction between Newcastle and Reno Junction which would give Newcastle a more direct link to the coal development area. Construction of this road is not expected to adversely affect any of the other transportation systems other than require an infrequent relocation of a pipeline or overhead transmission line.

Impact from the transportation of coal, its derivatives and service supplies is expected to manifest itself on highways and railroads only. The actual transportation of electricity by powerlines, coal by slurry pipeline, synthetic gas by pipeline, and water by aquaduct will not impact other systems.

The shipment of service supplies by highway will increase traffic between Newcastle and Reno Junction and between Casper and the two Cities of Gillette and Douglas. Increased traffic will induce incremental road wear and higher maintenance costs. The highway between Casper and Douglas is of high standard and appears able to withstand the increase in traffic without modification, but the route between Midwest and Reno Junction will require considerable upgrading to accommodate service supplies traffic (see Figure 80, Chapter IV, for location).

The existing railroad line was built a number of years ago to a standard that did not contemplate the shipment of a large number of heavy trains hauling coal on a daily basis. This line will thus experience rapid deterioration from its present condition and will require significantly large amounts of capital to maintain it at a standard high enough to keep accident probability low. Burlington Northern is planning and programming for the upgrading of all lines which will experience coal train traffic. Upgrading is usually accomplished by replacing deterioriated ties and laying a heavier grade of rail. Where the main line crosses highways or roads, minor delays may be caused by this upgrading.

Land Tenure

The impending development of the Eastern Powder River Coal Basin has already impacted land tenure. The recent trend of change in ownership from individual to corporate ownership is apparently in anticipation of issuance of additional federal coal leases and pending approval of mining plans on existing coal leases. Many companies are acquiring land in the name of the company, a subsidiary ranching operation, or a subsidiary mining operation. The general impact of change in ownership is to reinforce the general trend of deemphasis of agricultural and grazing land use with the possible outcome that once these lands are corporately owned, they may be held as investment properties and perhaps permanently removed from their original agricultural use. Present ranchers will have to buy comparable property elsewhere, get by with less acreage in their operation, arrange a lease and repurchase agreement, or get out of the ranching business entirely.

Conversations with the county assessor's offices in Campbell and Converse Counties and with numerous other sources provide only a wide range for the number of private acres that have passed into corporate ownership. These sources estimate that over the last five years 30,000 to 50,000 acres in each county have passed from private to corporate ownership. Many companies are still in the negotiation stage of their land purchases, and an accurate estimate of total acreage involved is unavailable.

Socio-Economic Conditions

The general approach and methodology utilized in analyses of impacts on the socio-economic baseline conditions of the study area is contained in Appendix C.

Development of the coal resources of Campbell and Converse Counties with associated increases in employment and population will have varying impacts on the socio-economic conditions of the basic study area and surrounding areas. In fact, the increase in population which will occur is the foundation and cause of many of the secondary impacts associated with coal development.

Population

Population projections for the cities and counties of the Eastern Powder River Coal Basin from 1980 to 1990 are only estimates of conditions considered likely to occur, not predictions. The model from which the population estimates were developed is located in Appendix C.

Projected population distribution

In the eight-county region (Campbell, Converse, Crook, Johnson, Natrona, Niobrara, Sheridan, and Weston) population has been projected to increase from 107,364 in 1970 to approximately 167,000 in 1990 as a consequence of forthcoming coal and other industrial development (Table 16). During this 20-year period, population will have expanded in the eight-county region approximately 55 percent. The most populous county will continue to be Natrona with an anticipated 1990 population of 61,800 which represents an increase of 20.6 percent relative to the 1970 population of 51,264. Campbell County will experience the greatest percentage increase of any county in the region during the period 1970 to 1990 (Figure 8).

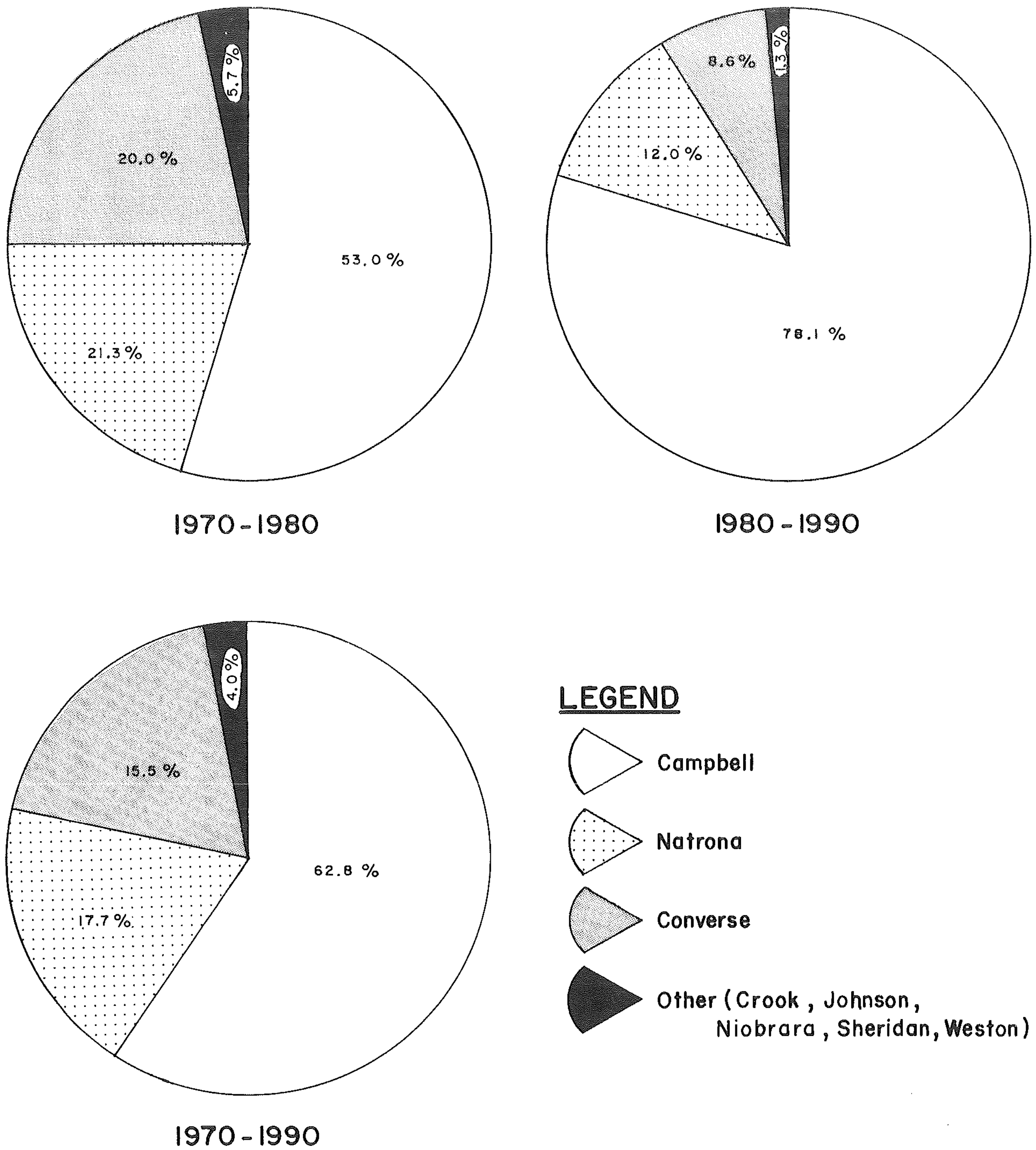


Figure 8

County Growth as a Percent of Regional Growth

Population will have tripled from a 1970 total of 12,597 to a projected 1990 level of 50,400. Converse County will encounter population expansion of 156 percent between 1970 to 1990. Population will increase from 5,938 in 1970 to 15,200 in 1990. The population of Johnson County will grow from an existing level in 1970 of 5,587 to a total in 1990 of 7,400, representing a 32.5 percent increase from 1970 to 1990. The Counties of Crook, Sheridan, and Weston will experience only slight population increases from 1970 to 1990 with the growth rate during that time period not exceeding four percent. Of the eight counties, only Niobrara will have less population in 1990 than 1970. Population will drop from a 1970 level of 2,924 to a 1990 level of 2,600 for a 20-year rate of decrease of 11.1 percent.

Table 16

Population Projections

	1980	1985	1990
Campbell	32,200	46,600	50,400
Converse	13,200	14,900	15,200
Crook	4,500	4,600	4,600
Johnson	7,500	7,400	7,400
Natrona	59,000	60,400	61,800
Niobrara	2,800	2,700	2,600
Sheridan	18,200	18,300	18,500
Weston	6,300	6,300	6,500
Total	143,700	160,200	167,000

Campbell County. Campbell County will be the second most populous county in the Eastern Powder River Coal Basin with an anticipated 1990 population of 50,400, 300 percent higher than the current 1970 population of 12,597. Campbell County between 1970 to 1990 will capture over 60 percent of the anticipated regional population increase of approximately 63,000

(Figure 9). Population growth will be most pronounced from 1975 to 1980 when population will nearly double. Growth will continue to rise from 1980 to 1985, increasing from 32,200 to 45,600. The five-year growth rate from 1980 to 1985 is 41.6 percent. From 1985 to 1990, population will increase at a rate of 10.5 percent which is less than the previous five-year period but still the highest regionally. The City of Gillette will grow from a 1970 total of 7,194 to a 1990 total of 28,000 (Table 44, Appendix C). The projected 20-year growth rate for Gillette is 289.2 percent.

Converse County. Converse County will be the fourth most populous county in the region by 1990 having been fifth in 1970. Population will rise from 5,938 in 1970 to 15,200 in 1990, representing a 20-year growth rate of 156.6 percent. Converse County between 1970 to 1990 will capture 15.5 percent of the anticipated regional population increase of approximately 63,000. Population growth will be most pronounced from 1970 to 1975, reaching a total of 9,900. Population in 1975 will have risen by 66.7 percent from a 1970 level of 5,938. Growth will continue to rise from 1975 to 1980, increasing from 9,900 to 13,200 for a five-year growth rate of 33.3 percent. From 1980 to 1990, population will grow but more slowly. In 1990, the population of 15,200 will be about 2,000 greater than the anticipated 1980 population. In 1990, Converse County will have two urban places[1] as opposed to one in 1970. While Douglas will grow from a 1970 total of 2,677 to a 1990 total of about 7,000, Glenrock will increase during the same time period from 1,515 to nearly 4,000 (Table 44, Appendix C).

Crook, Johnson, Natrona, Niobrara, Sheridan and Weston Counties. Population growth from 1970 to 1990 will be most prominent in Johnson and

[1]Urban place is defined as a city with a population greater than 2,500.

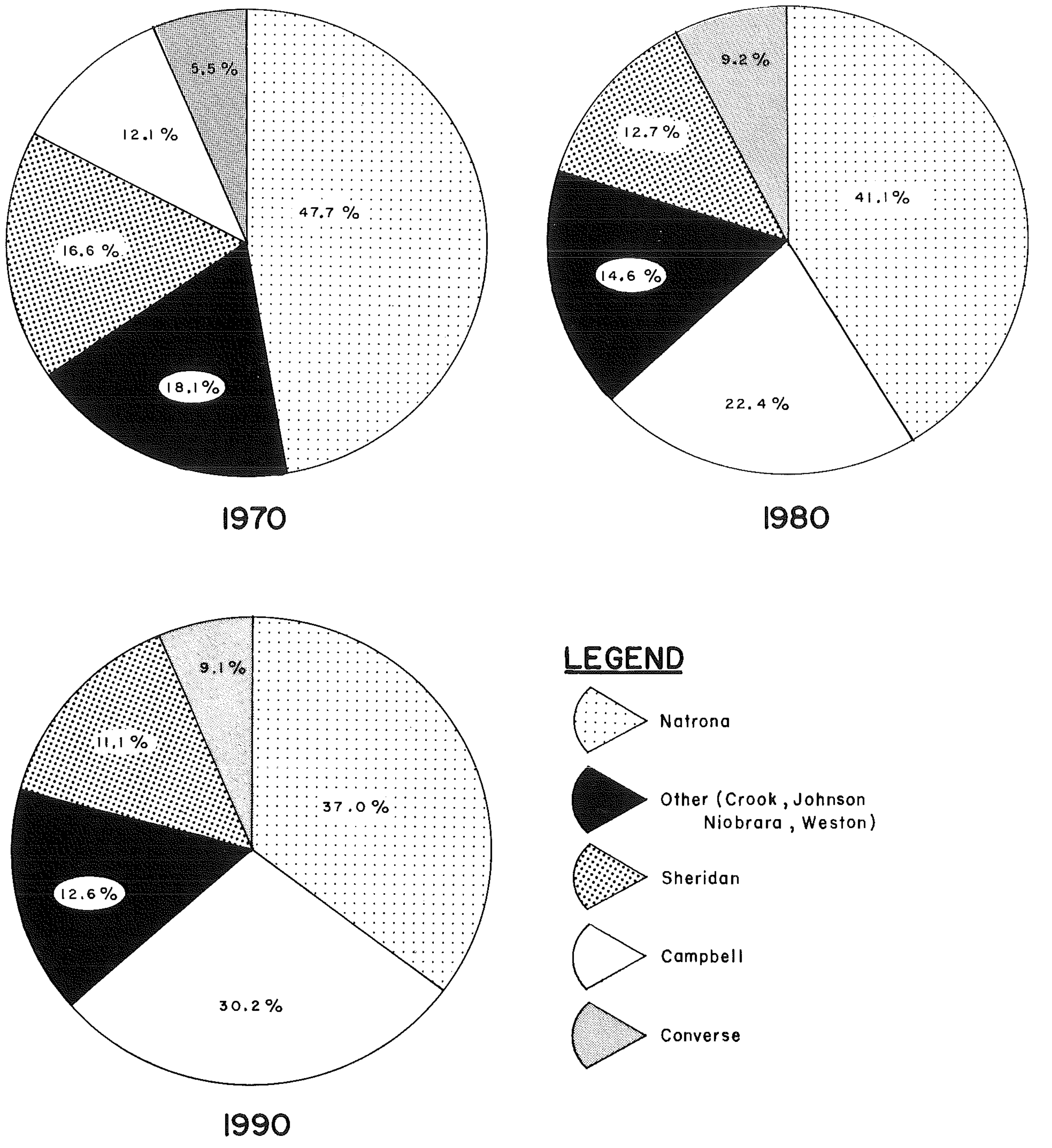


Figure 9

Population Distribution, Powder River Basin, Wyoming, 1970, 1980, 1990

Natrona Counties. During this time period, population in Johnson County will increase by 32.5 percent from 5,587 to 7,400; population in Natrona County will grow by 20.6 percent from 51,264 to 61,800. Population in Crook, Sheridan, and Weston Counties will experience no more than four percent growth from 1970 to 1990. Only Niobrara will lose population. Population in Niobrara County will be 2,600 in 1990 which is a decline in 20 years of 11.1 percent. This six-county subregion will capture about 25 percent of the anticipated 1990 regional population increase of approximately 6 0,000. Natrona County will receive approximately 10,500 or nearly two-thirds of the 1990 subregional growth with the Counties of Crook, Johnson, Sheridan, and Weston sharing in the other one-third. Population growth between 1970 and 1990 for the Counties of Crook, Sheridan, and Weston will be stable and inconsequential except for Niobrara which will consistently lose population. The City of Casper will remain the largest city in the study area. The population of Casper will grow between 1970 and 1990 from 39,361 to about 47,000. Of the other urban places in the six-county subregion, only the City of Buffalo will experience significant population growth. Buffalo will grow from 3,394 in 1970 to approximately 4,500 in 1990 which is a 20-year growth rate of 32.6 percent. The Cities of Newcastle and Sheridan will encounter very little growth, i.e., less than four percent from 1970 to 1990.

Urban growth centers. There will exist two major population centers in the Eastern Powder River Coal Basin by 1990 compared to a single center in 1970. Prior to coal and other industrial development, Casper in Natrona County was the principal urban center. Currently, Sheridan is the second most populous city in the Powder River Basin and serves as a focus for county activities. Energy development and construction of a railroad line from

Gillette to Douglas will alter the population balance. By 1990 population in the City of Gillette will reach 28,000, while population in the City of Casper will be 47,000. Gillette rather than Sheridan will become the second most populous city. Although Casper historically has been the major urban center because of its relative greater size, Gillette with its increased population may begin to attract certain economic activities which otherwise would have preferred to locate in Casper. Consequently, there could be two population foci developed in the Eastern Powder River Coal Basin by 1990 (Table 44, Appendix C).

Employment

Employment projections are based on estimated coal production and facilities (mines, gasification, and power generation) shown in Assumptions and Analysis Guidelines, Chapter II, Part I. County-by-county employment projection figures assume that employment and residence are coincidental, but where anomalies in this assumtion may exist they are pointed out. Projection Tables 45 through 53 (Appendix C) were provided by the Water Resources Research Institute, University of Wyoming, based on the employment and population projection model used for the Northern Great Plains Resource Program social and economic impact study. Figure 10 graphically displays changes in sector employment for the region and Campbell and Converse Counties. Figures 11, 12 and 13 display projected employment and population growth.

Regional employment is impacted by a projected period of employment growth that could be described as enormous for the period 1970 to 1980 and substantial for the period 1980 to 1990 (Table 45, Appendix C).

Total employment for 1970 to 1980 is projected to increase by 41.4 percent (17,060 new jobs) and 20.6 percent (11,985 new jobs) from 1980

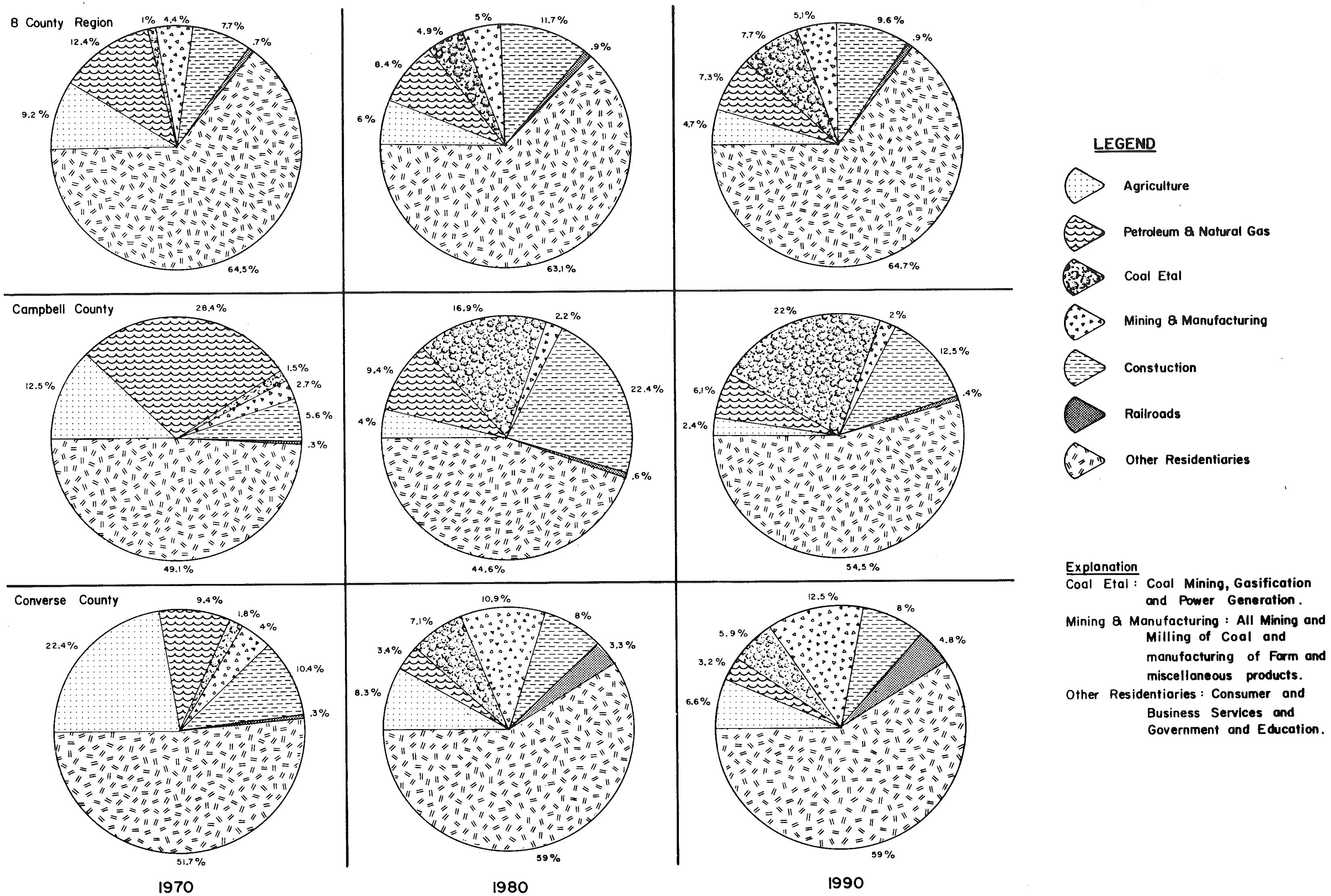


Figure 10
Employment by sectors for 1970,1980 and 1990.

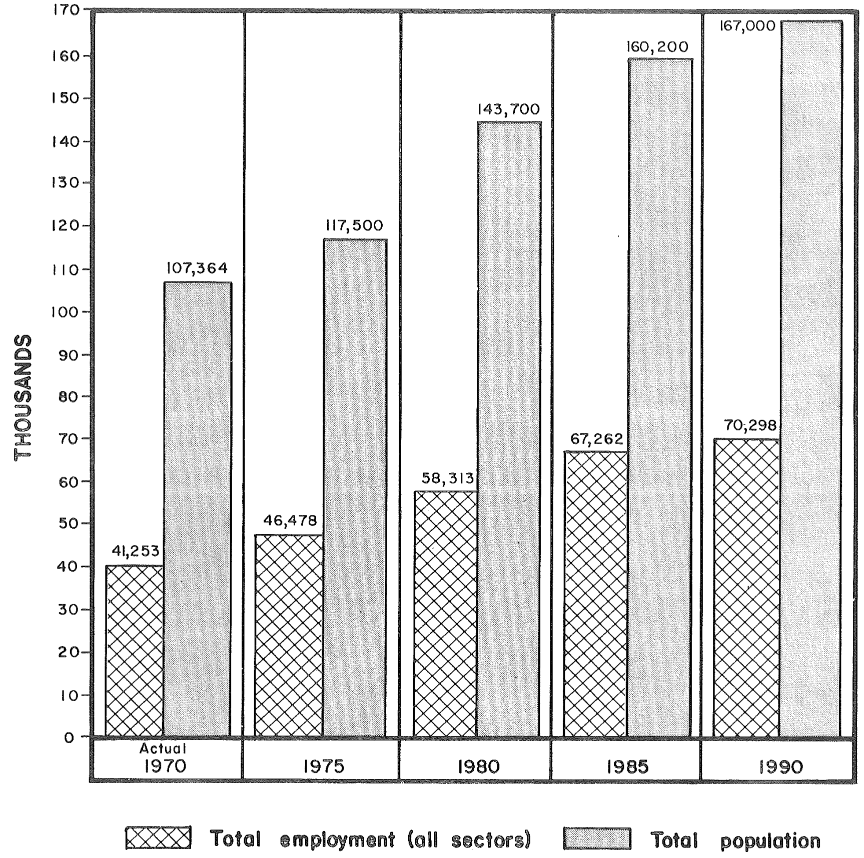


Figure 11
Total Employment and Total Population Projections for the Eight County Region 1970-1990.

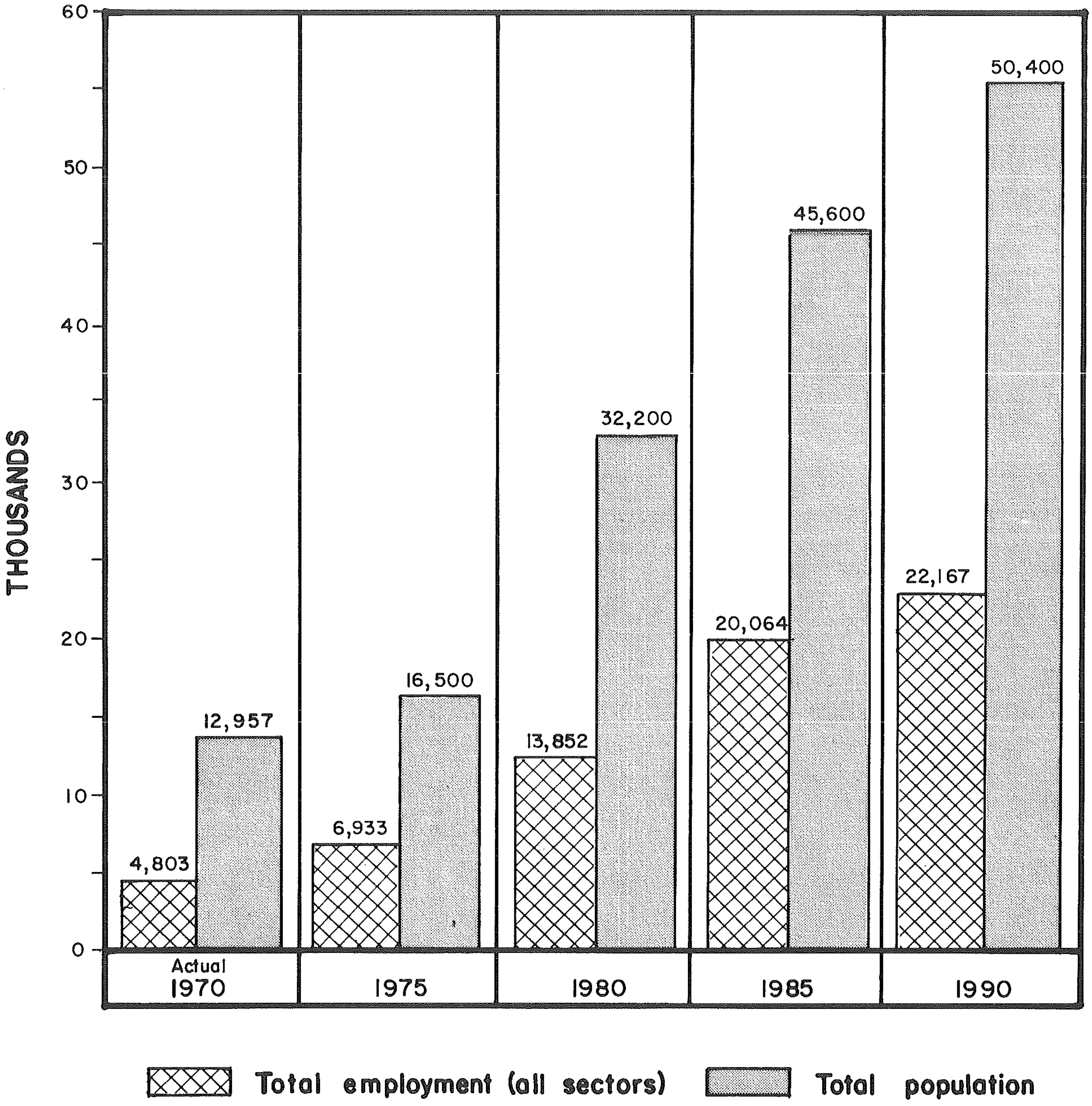


Figure 12
Total Employment and Total Population Projections for Campbell County 1970-1990.

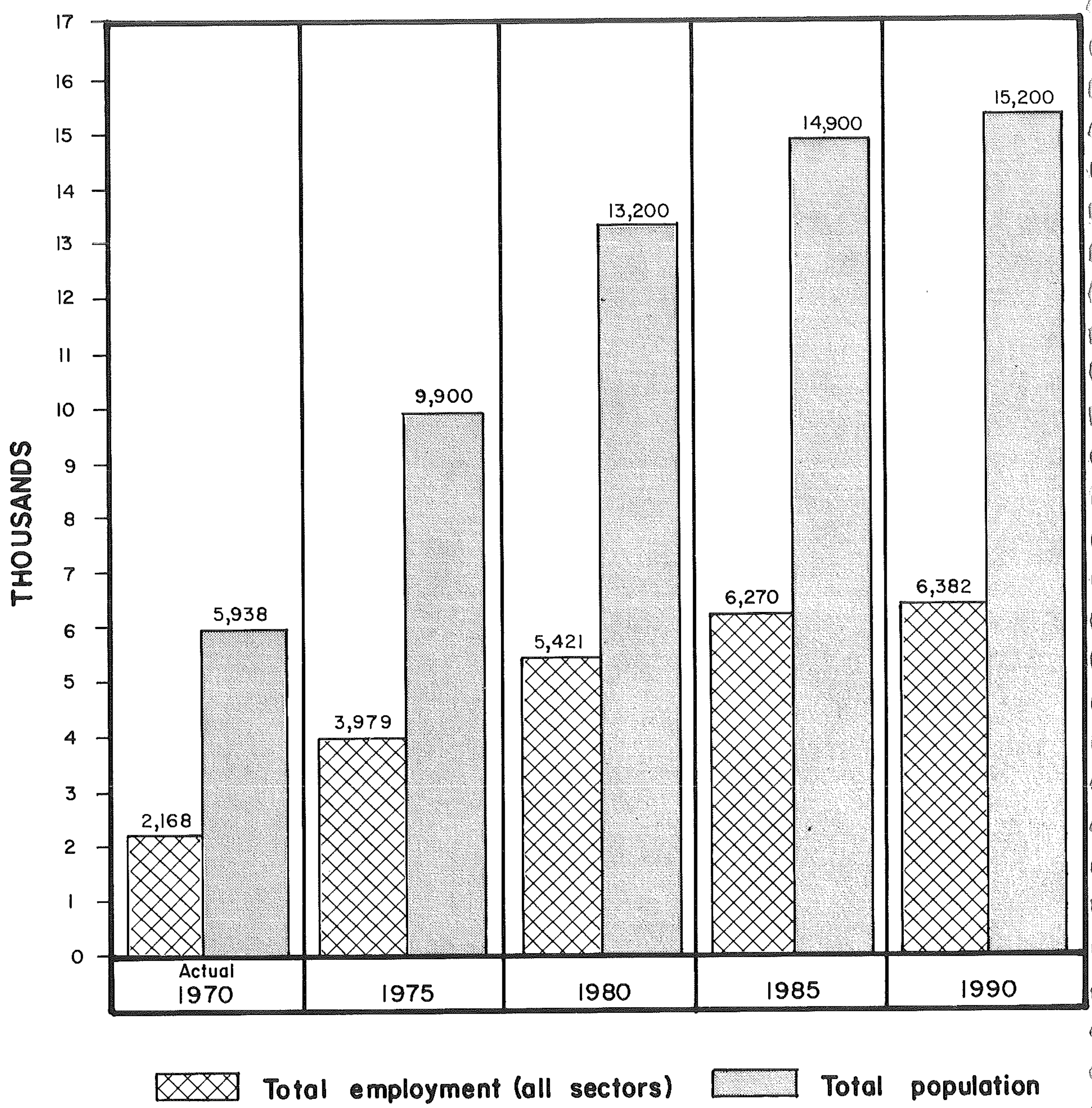


Figure 13
Total Employment and Total Population Projections
for Converse County 1970-1990.

to 1990. After 1985 the employment surge begins to taper off due principally to the lack of introduction of any new coal gasification plants (synthetic gas in tables) and a reduced rate of increase of coal mining employment.

Employment in coal mining, coal gasification, power generation, railroads, construction, and uranium mining and milling sustains the greatest numerical and percentage growth increase during 1970 to 1990 (10,019 new jobs). All but the latter are coal related and induce substantial growth in other residentiary sectors. A shortage of available labor for coal mining, coal gasification, and construction will likely induce a bidding war for the labor supply in petrochemicals, other residentiaries, and agriculture. Labor will likely be attracted from the latter to the former. Despite this movement of labor across sectors, there is a strong possibility of a labor shortage in the coal-related sectors and most particularly in construction. Map 6, Appendix A shows coal related labor employment locations.

Certain employment sectors will be impacted as a direct result of coal development and employment. Agriculture may be the most impacted by loss of employment to coal-related industries. Agriculture cannot be expected to offer salaries comparable to those of the energy industry and is expected to lose 12.3 percent of its employment (a loss of 465 employees) between 1970 and 1990. Its share of regional employment will also drop from 9.2 percent in 1970 to 4.7 percent in 1990 (Figure 10). What impact this may have on agricultural productivity is speculative. Labor losses could be offset by increased mechanization or improved efficiency.

The railroad industry, which lost employment between 1960 and 1970 (from 518 to 305) and would be expected to continue this trend without coal freight, will likely reverse this trend and by 1980 employ as many people as it did in 1960.

Impact from coal gasification employment will likely occur initially between 1975 and 1980, requiring about 800 permanent employees. However, greater than this will be the prior demand for construction employees that may reach a peak of 3,000. Construction could take three years per plant.

Construction employees will be in heavy demand which is expected to peak between 1980 and 1985. Large numbers of construction workers will be required through 1990 for construction of coal gasification plants, power generation plants, and housing. The skilled labor required does not appear available in the area in the amount required for peak construction periods.

Impact on other residentiaries is a direct function of employment in the basic sectors (only construction and other residentiaries are considered nonbasic or secondary). Although a precise numerical relationship does not exist between employment in the basic sector plus construction and employment in other residentiaries, a range can be made. For Campbell County (Table 46, Appendix C) for the years 1970 through 1990, the ratio of basic plus construction employment to total employment ranges from 0.56 to 0.45. Thus, one additional employee in a basic sector (coal, etc.) induces a total employment of 1.8 to 2.2 persons, the difference being attributable to other residentiaries. The figures are not as important as realizing that for each employee in coal mining, coal gasification or power generation, an additional employee position is induced in other residentiaries. Filling employment in this sector will lag behind employment in energy industries due to attraction of the available supply of labor to higher paying energy jobs. This opportunity for movement is generally considered beneficial to the employee. It should be emphasized that it will be difficult to fill jobs in the services sector (such as law enforcement) where salaries are fixed with no allowance for areas of inflated incomes. The consequences could be recruitment problems, inferior personnel and understaffing.

In summary, development of the coal resource will provide a large number of basic and secondary jobs, perhaps as many as 30,000 by 1990, which will compete fiercely for the available supply of labor. Skilled labor shortages

for construction peaks during coal gasification plant and generating plant construction may be severe and could be worsened by simultaneous plant construction. Impact identification on a county by county basis further isolates the location of these impacts.

Campbell and Converse Counties

Campbell County, and principally the City of Gillette, will likely experience the most impact within the eight-county region (Tables 54 through 56, Appendix C). The county is projected to experience significant employment growths in coal gasification, coal mining, power generation, railroading and construction from a total of 351 employees in 1970 to 5,523 in 1980 (Table 46, Appendix C). This is a change of 7.4 percent of county employment to 39.9 percent. The bulk of total regional employment in coal mining, coal gasification, power generation, and construction is expected in Campbell County. With a 1970 unemployment level of 2.6 percent, there is an obvious shortage of available labor.

The economic structure of Converse County is likely to be impacted. Agriculture will no longer be dominant and will fall from 22.4 percent of county employment in 1970 to 8.3 percent in 1980 and 6.6 percent in 1990 (Figure 10, this chapter; and Table 47, Appendix C). In its place will be an economy based more on energy and railroad transportation. Power generation and coal mining, which employed 39 persons in 1970, are expected to employ 382 in 1980. The bulk of railroad employment will occur in Converse County. Uranium mining and milling, however, is expected to become the primary employment sector by 1980. One significant change could largely alter the impact on Converse County. The change of the location of one of the coal gasification plants from Campbell County to Converse County would

make coal related employment in mining, gasification, power generation, railroads, and construction the largest employer in the county. Thus, employment impacts would change from being principally noncoal related to directly coal related, which would require the importation of a large amount of labor to fill employment vacancies with subsequent impacts on other socio-economic sectors discussed and most immediately population and housing. Converse County could conceivably be placed in the position where a large number of its residents are commuting and employed outside the county if the coal gasification plant is located in southern Campbell County.

Crook, Johnson, Natrona, Niobrara, Sheridan, and Weston Counties

Crook, Johnson, and Sheridan Counties play an insignificant role in the coal development projected to take place in Campbell and Converse Counties and show no change in employment directly attributable to it. Johnson and Sheridan Counties are, however, potentially impacted by coal development within Johnson County and southern Montana, but an analysis of this impact is beyond the scope of this statement.

Table 50, Appendix C, projects rather moderate growth for Natrona County through 1990, but this growth is only partially attributable, if at all (and only secondarily), to coal development. Any impacts on employment in Natrona County from coal development are considered minor.

Niobrara County, like Crook, is faced with little impact from energy development. However, there is one firm proposal to ship coal via a slurry pipeline that could create a number of temporary and permanent jobs within the county. Few specifics, other than those cited within the

Modes of Distribution section, Chapter II, Part I, are known at this time. A preliminary estimate of 1,000 construction workers will be needed for two years, and a permanent crew of 200 will be employed.

Impact on Weston County, like Niobrara, is dependent on construction of a transportation link. The impact depends entirely on construction of a highway between Newcastle and Reno Junction in Campbell County (Tables 48 through 52, Appendix C).

Income

Income levels for the entering coal or industrial worker will range from $10,000 to $15,000 per year. Whether or not these incomes are sufficiently attractive to lure employees to the Eastern Powder River Coal Basin is unknown. While incomes of the industrial workers will be high, incomes of the work force in supportive employment, e.g., government services and consumer services, may be relatively lower. The average income of the induced labor force will be greater than or at least equal to that of the region ($10,900). The effects of rising incomes and probabey inflation of prices and property values will be particularly adverse on that portion of the population living on fixed incomes, such as disabled, aged and welfare recipients. Although this condition is almost universal, rapid industrial growth could likely worsen the situation.

The Gross Regional Product (GRP) for the Powder River Basin will increase from an estimated 1970 level of $730,000,000 to a projected 1990 level of $1,240,000,000 to $1,410,000,000 (current dollars). Gross Regional Product is an income accounting tool which measures annually the value of economic goods and services. The estimated GRP was derived from data in a 1972 report of the Wyoming Department of Economic PLanning and Development (Burnett 1972, p. 2). Civilian income represents the income received by people for participation in current production (Burnett 1972, p. 12). Gross Regional Product is the product of employment and mean income when divided by the proportion of the civilian income to gross national product (Burnett 1972, p. 2).

The 1990 Gross Regional Product was computed for additional employment at the present regional mean income of $10,900 and at $15,000 per coal worker. As incomes for supportive employment are likely to approximate the mean income and given the anticipated relatively high income of the incoming industrial worker, a range for the 1990 GRP was developed.

Housing

Table 17 displays projected housing demand from 1980 to 1990 in five-year increments by county, urban, and rural areas within each county. Implicit in these projections are four major assumptions: (1) Those employees who work in a given county also reside in that county, (2) the incoming labor force will prefer to locate in urban and rural areas similar to the existing location patterns of 1970, (3) the percentage of urban and rural housing by county has been projected for the future at 1970 levels, and (4) projections of housing demand are based on 1970 household size for each respective city, rural area, and county. Because it is difficult to identify the location and commuting patterns of the arriving work force, these assumptions based on 1970 levels, have been used. Furthermore, these projections underestimate the housing demand of the population as they have not been increased to account for the vacancy rates which would occur in the housing market.

The housing demand for the study area will be 46,400 units in 1980 and 53,500 units in 1990 relative to the 1970 base of 37,463. Approximately 8,900 more units will be required regionally in 1980 than existed in 1970 to meet the rising population and resultant demand. The 1990 housing demand is 6,000 units more than 1970 totals and 7,100 units more than existed in 1980. The greatest increases in housing demand will occur in Campbell and Converse Counties, primarily due to coal and other energy related development. Of the remaining six counties only Natrona and Johnson show a demand that

Table 17

Difference between Projected Housing Demands and 1970 Housing Stock by County of the Powder River Basin, Wyoming*

	1970	1980		1985		1990	
County***	Stock	Demand**	1970-1980 Difference	Demand**	1970-1985 Difference	Demand**	1970-1990 Difference
Campbell	3,937	9,500	-5,600	13,400	-9,500	14,800	-10,900
Gillette	2,228	5,400	-3,200	7,600	-5,400	8,400	- 6,400
Rural	1,709	4,100	-2,400	5,800	-4,100	6,400	- 4,700
Converse	2,247	4,400	-2,200	5,000	-2,800	5,100	- 2,900
Douglas	1,029	2,000	-1,000	2,300	-1,300	2,300	- 1,300
Rural	1,218	2,400	-1,200	2,700	-1,500	2,800	- 1,600
Crook	1,576	1,400	200	1,400	200	1,400	200
Urban	-----	-----	------	------	------	------	--------
Rural	1,576	1,400	200	1,400	200	1,400	200
Johnson	2,158	2,600	- 400	2,600	- 400	2,600	- 400
Buffalo	1,319	1,600	- 300	1,600	- 300	1,600	- 300
Rural	839	1,000	- 200	1,000	- 200	1,000	- 200
Natrona	17,228	19,000	-1,800	19,500	-2,300	19,900	- 2,700
Casper	13,426	14,800	-1,400	15,200	-1,800	15,500	- 2,100
Rural	3,802	4,200	- 400	4,300	- 500	4,400	- 600
Niobrara	1,330	1,000	300	1,000	300	1,000	300
Urban	------	------	------	------	------	------	--------
Rural	1,330	1,000	300	1,000	300	1,000	300
Sheridan	6,799	6,500	300	6,600	200	6,600	200
Sheridan	4,434	4,200	200	4,300	100	2,300	100
Rural	2,365	2,300	100	2,300	100	2,300	100
Weston	2,188	2,000	200	2,000	200	2,100	100
Newcastle	1,268	1,100	200	1,100	200	1,200	100
Rural	920	900	------	900	------	900	--------
Study Area	37,463	46,400	-8,900	51,500	-14,000	53,500	-16,000

*Demand and Difference between Projection Years and 1970 Stock rounded to nearest hundred.
**Population per occupied housing unit derived from Table I for each respective county and held constant from 1980-1990.
***The percentage of urban and rural housing by county has been projected at 1970 levels.

will necessitate the construction of additional housing units assuming that the present housing stock remains in use. The other four counties will experience a decreased housing demand relative to 1970 levels.

Campbell County

Campbell County will require approximately 9,500 units in 1980 which is 5,600 units more than the 1970 total of 3,937 units. By 1990 the population of Campbell County will demand 14,800 housing units which is 10,900 units more than the prevailing stock in 1970 and 5,300 units more than the estimated 1980 stock. Thus, the housing stock in Campbell County by 1990 will need to expand by nearly four times to meet the anticipated demand.

Converse County

Converse County will have an estimated housing demand of 4,400 units in 1980 and 5,100 units in 1990. The 1980 demand is about 2,200 units more than the existing 1970 stock of 2,247 units, and the 1990 demand is 2,900 units more than 1970 levels and 665 units more than estimated 1980 levels. The housing stock by 1990 must more than double to meet the anticipated demand.

Crook, Johnson, Natrona, Niobrara, Sheridan, and Weston Counties

Johnson and Natrona Counties will experience a growing population which will necessitate the construction of new housing, while the other four counties will need no additional new housing other than that existing in 1970. The population of Johnson County will demand 2,600 units by 1980 and continue to demand that same number of units by 1990. As population in Johnson County by 1990 will decrease relative to 1980, the housing stock having expanded by 400 in 1980 as compared to 1970 levels will be more than

sufficient to fulfill 1990 demands. Natrona County will have an estimated housing demand of 19,000 by 1980 and 19,900 by 1990 compared to the 1970 total of 17,228 units. Niobrara County will encounter a housing demand in 1990 of 1,000 units which is approximately 25 percent less than the 1970 housing stock of 1,330.

Cost of new housing

The influx of a work force with associated families will create an immediate housing demand in the Counties of Campbell, Converse, Johnson, and Natrona. At present levels, the supply of housing in these counties is inadequate to meet the projected housing demands. Consequently, new housing would be required if the demand is to be met.

The cost of a typical single-family residential unit in the Eastern Powder River Coal Basin based on 1972 data can be expected to vary from $26,000 to $39,000 for a range of 1,000 to 1,500 square feet. These estimates have been developed using data furnished by the National Association of Home Builders (NAHB) and interviews conducted with banks and builders in Cheyenne, Wyoming (Table 57, Appendix C).

Ability of consumers to pay for housing

Households of the entering population with a gross income ranging from $10,000/year to $18,000/year can be expected to correspondingly purchase housing of $18,000 to $33,000. These estimates have been based on (1) interviews with three major banks in Cheyenne, Wyoming, (2) current interest rates, (3) a five-percent down payment, (4) a 30-year mortgage, and (5) an expenditure of about 25 percent of the gross monthly income on housing related items including mortgage, interest, property taxes, and insurance. The amount of housing the entering worker and his family can reasonably afford to purchase is

dependent on income and overall financial status. As it is difficult to assess the wealth of the arriving population by family, the above estimates of the amount of housing that a family may purchase is thus more reliant on annual income.

Responsiveness of the housing market
to predicted housing demand

The housing market will be unresponsive to projected housing demand as the price of new housing will exceed the ability to pay for most of the arriving work force, except for the higher income levels ($15,000/year and higher), which can afford houses no larger than 1,200 square feet. Because the incoming population will have incomes generally insufficient to stimulate housing production, a shortage of housing may result. The arriving population, when confronted with an inadequate supply of housing, will bid up the prices of the current stock. Additionally, the entering population as well as those displaced by the higher prices may seek alternative forms of housing, namely the mobile home.

A critical housing situation will exist when the population related to coal development in Campbell and Converse Counties enters the region. As the median value of an owner-occupied home in 1970 in the eight-county study area was approximately $16,000, it would seem that the entering population would be able to afford housing within its financial capabilities. The problem is that the entering population will be so numerous and have incomes insufficiently high that the current supply will be unable to expand and absorb the demand generated by the arriving population. There will be a shortage of permanent homes in the region, especially in Campbell and Converse Counties where the price of new conventionally built housing exceeds that which a majority of the arriving population can be expected reasonably to

pay. People in income levels between $10,000/year to $18,000/year will not be able to purchase a home larger than 1,300 square feet. Households with incomes greater than $15,000/year will be able to purchase housing but the living area will likely be no greater than 1,000 to 1,200 square feet.

Since there will be an influx of new population which in the whole have incomes deficient to generate a housing market response, there will appear dislocations due to price or changes in present housing consumptive patterns. In this instance, the entering work force characterized by incomes greater than the existing average will bid prices up for all units. Many owners of single-family homes will prefer to sell their homes at a substantial profit, while renters of single-family and multifamily units may be required to move as prices rise to levels they are no longer willing and able to pay. To obtain housing they can afford within the same community, former renters may accept housing which may be substandard. The shortage of housing will necessitate maintenance of substandard units in the housing stock, although these substandard housing units otherwise would have dropped out of circulation had not the demand for housing dramatically risen, given a relatively inelastic supply. Other families may select housing units of lesser sizes which may lead to overcrowded conditions. At present, 13.2 percent of the population in Campbell County live in housing considered overcrowded. This percentage would be elevated further as individual households respond to the changing housing market. Finally, many families may select the mobile home as the only means by which to solve their housing demands.

The mobile home satisfies housing demand more in the short than long term. While the life of a mobile home can vary substantially depending on make and model, climate, and care taken by its occupants, some indication

of its expected life is suggested by the typical financing period of 7 to 12 years as compared to the 30-year (or longer) mortgage available for purchase of conventional single-family homes (U.S. Congress, House 1968, p. 439). The mobile home depreciates much more rapidly than the conventionally built home because of its lighter construction and the obsolescence of nonreplaceable built-in elements (President's Committee on Urban Housing 1968, p. 156).

The City of Gillette is a clear historic example where a sudden, arriving population could not locate housing and necessarily resorted to the purchase of mobile homes. In 1970, 42.3 percent of the total year-round housing stock was mobile homes. If the mobile home is the only form of housing available at the price the incoming population is willing to pay, the percentage of mobile homes in the total housing stock will increase greatly. If the housing mix becomes such that mobile homes constitute 50 percent or more of the housing stock in Gillette and Campbell County and given the short expected life of the mobile home relative to the conventional home, there exists the potential of widespread deterioration on an enormous scale after at least two decades. Further, as there are no controls on the quality of mobile homes sold in the state, it is quite likely that mobile homes would be of a lesser quality than where such controls exist. The adverse impact resulting from no state controls would be the purchase of mobile homes which could be dangerous under certain climatic conditions. Because construction would be of lower quality, the rate of depreciation would be accelerated.

The Denver Office of the Department of Housing and Urban Development has suggested to the Casper Office of the Federal Housing Administration that the present share of mobile homes in Campbell County is highly disproportionate and that more mobile homes should be actively discouraged. While more mobile homes could be purchased regardless of HUD-FHA policy suggestion, it is interesting to note that if new mobile homes could be discouraged while conventionally built homes remain too expensive, the only alternative housing types would be townhouses and apartments. Apartments would be suitable for single individual and married couples but probably too confining for large families. HUD-FHA has recommended that efforts in the future be directed toward apartments and sales units. Sales units could include condominiums and cooperatives on small scale to test the market. If the public preference for housing could shift from single family detached to single family attached units and multifamily units, then perhaps the housing demands of the incoming population can be satisfied.

Conclusion

The majority of the arriving population probably cannot afford new housing which will create a severe housing problem, especially in Campbell and Converse Counties. As individuals respond to the lack of available housing, they will accept inferior housing quality and living conditions and/or select the mobile home as a housing alternative. The mobile home may prove adequate as short-term housing but does not compare to the durability of the conventionally built home. Unless other housing forms are introduced and accepted, the

mobile home will become the dominate form of housing in Campbell County and to a lesser extent in Converse County.

Public education

Development of coal and energy-related resources in the study area will cause an increase in the regional population between now and 1990. With a rise in population levels and immigration of various work forces with associated families, public school enrollments will realize substantial increases in Campbell and Converse Counties. Increasing student enrollments in turn would impact enrollment capacities of existing school district facilities and teaching staffs.

In order to determine student enrollment projections for 1980, 1985, and 1990, certain factors had to be assumed. The projections are based on the following demand factors and assumptions which are explained further in Appendix C:

1. There will be 250 families per 1,000 population; each family unit will consist of 3.5 persons. (The difference is single people.)

2. Each family unit will reside in the county in which its head of household will be employed.

3. There will be 1.0 school age child per family unit or 250 school age children per 1,000 population.

4. The number of school age children per family by school grade level is provided below:

Type of School	Grade Levels	Number of School Age Children per Family
Elementary	K-6	0.50
Junior High	7-9	0.25
Senior High	10-12	0.25

Enrollment projections and distribution

Table 18 displays student enrollment projections and distribution in the region for the 1980 to 1990 period. Enrollment projections have been aggregated at the county level for those counties with more than one school district since it is difficult to determine in which school district incoming families will establish residency.

As indicated in Table 18, Campbell and Converse Counties will experience the most substantial impact from student enrollments. Between 1974 and 1990, school enrollments would more than quadruple in Campbell County from 3,022 to 12,660 and more than double in Converse County from 1,842 to 3,875. Johnson, Natrona, and Sheridan Counties would experience moderate increases, while school enrollments would remain relatively stable in Crook, Niobrara, and Weston Counties.

The distribution of public school children (Table 18) will also change substantially in the region. At present, Natrona County has the largest share (41.3%) of the regional student enrollment total; however, by 1990, the Natrona figure will shrink to 36.9 percent. This reduction can be attributed primarily to increasing school enrollments in Campbell and Converse Counties. Campbell County, which currently has 11.3 percent of the regional enrollment total, will assume a significant educational role by the year 1990 with over 30 percent of the region's total enrollment.

Impacts on existing school facilities
and full-time teacher staffs

By 1980, the influx of a work force (including temporary construction and permanent workers) and associated families would place significantly large demands on school enrollments of school districts in Campbell and Converse Counties. At present, the capacities of existing schools and

Table 18

Enrollment Projections and Distribution
Powder River Basin Region
1980-1990

	Actual 1974	Percent Region Total	1980	Percent of Region Total	1985	Percent of Region Total	1990	Percent of Region Total
Campbell	3,022	11.3	8,050	22.4	11,400	28.5	12,600	30.1
Converse	1,848	6.9	3,300	9.2	3,725	9.3	3,875	9.3
Crook	1,178	4.4	1,125	3.1	1,150	2.9	1,150	2.7
Johnson	1,224	4.6	1,875	5.2	1,850	4.6	1,850	4.4
Natrona	13,181	49.3	14,750	41.1	15,100	37.7	15,450	36.9
Niobrara	604	2.2	700	1.9	675	1.7	650	1.6
Sheridan	4,027	15.1	4,550	12.7	4,575	11.4	4,625	11.1
Weston	1,671	6.2	1,575	4.4	1,575	3.9	1,625	3.9
Region Total Enrollment	26,755	100.0	35,925	100.0	40,050	100.0	41,825	100.0

number of full-time teachers in these counties would be totally inadequate to cope with enrollment projections for 1980 to 1990. While Sheridan, Johnson, and Natrona Counties would continue to operate near maximum capacity levels, school districts in Crook, Niobrara, and Weston Counties would realize very minimal changes in 1980 to 1990 enrollments and would operate below maximum capacity levels by more than 25 percent.

Campbell County. The most significant impacts on public education would take place in Campbell County which would realize a phenominal 300 percent enrollment increase between 1974 and 1990. Table 19 provides a detailed analysis of the impacts of increasing enrollments on existing school capacities and full-time teaching staffs. The most critical period of student enrollment growth would occur between 1974 and 1980, when enrollment would increase by 166.4 percent from 3,022 to 8,050 students. Existing school facilities and teaching staffs would be unable to absorb this large increase. By 1980, school enrollments would exceed maximum capacity levels by 97.5 percent in elementary schools and 82.7 percent in both junior high and senior high schools. The school district would require approximately 200 more full-time teachers and school facilities with enrollment capacities to accommodate an additional 3,810 students, which includes 1,990 elementary, 910 junior high, and 910 senior high school students.

By 1990, the enrollment capacity and existing number of full-time teachers would need to triple in order to accommodate the projected enrollment of 12,600 students.

Converse County. The Douglas and Glenrock school districts in Converse County would realize a 109.7 percent increase in student enrollments between 1974 and 1990. Table 20 details the impacts of increasing enrollments on existing school capacities and full-time teacher staffs.

Table 19

Campbell County Unified School District
Enrollment Projections, Capacity Levels, and Teacher Needs

	Actual 1974*	Projections 1980	1985	1990
Total Enrollment				
Projected Number of Pupils**	3,022	8,050	11,400	12,600
Number over (+), under (-) capacity***	- 768	+3,810	+7,160	+8,360
Percent over or under capacity	-20.3%	+89.9%	+168.9%	+197.2%
Elementary Enrollment (K-6)				
Projected Number of Pupils#	1,722	4,030	5,700	6,300
Number over (+), under (-) capacity	- 318	+1,990	+3,660	+4,266
Percent over or under capacity	-15.6%	+97.5%	+179.4%	+208.8%
Junior High Enrollment (7-9)				
Projected Number of Pupils	699	2,010	2,850	3,150
Number over (+), under (-) capacity	+ 49	_ 910	+1,750	+2,050
Percent over or under capacity	+ 7.5%	+82.7%	+159.1%	+186.4%
Senior High Enrollment (10-12)				
Projected Number of Pupils	601	2,010	2,850	3,150
Number over (+), under (-) capacity	- 499	+ 910	+1,750	+2,050
Percent over or under capacity	- 45.4%	+82.7%	+159.1%	+186.4%
Full-time Teachers				
Projected Number Required##	204	405	570	630
Deficit###	0	- 201	- 366	- 426

*1974 figures represent existing levels in enrollments and teaching staffs.
**Refer to Appendix C, Table 70 for derivation of projections.
***1974 maximum enrollment capacity total equals 3,790, which includes 2,040 elementary, 650 junior high and 1,100 senior high student enrollment capacities. By 1980, the maximum enrollment capacity total will be 4,240 with an increase in junior high school enrollment capacity to 1,100 students.

#Includes figures for rural schools (grades K-8).
##Based on students to teacher ratios of 20 to 1.
###Based on Fall 1973 level of 204 full-time teachers.

Table 20

Converse County Unified School District #1 (Douglas) & #2 (Glenrock)
Enrollment Projections, Capacity Levels, and Teacher Needs

	Actual 1974*	Projections 1980	1985	1990
Total Enrollment				
Projected Number of Pupils**	1,848	3,300	3,725	3,875
Number over (+), under (-) capacity***	- 272	+ 750	+1,130	+1,280
Percent over or under capacity	-12.8%	+27.2%	+43.5%	+49.3%
Elementary Enrollment (K-6)				
Projected Number of Pupils#	998	1,650	1,865	1,935
Number over (+), under (-) capacity	- 172	+ 305	+ 520	+ 590
Percent over or under capacity	-14.7%	+22.7%	+38.7%	+43.9%
Junior-Senior High Enrollment (7-12)				
Projected Number of Pupils	850	1,650	1,860	1,940
Number over (+), under (-) capacity	- 100	+ 400	+ 610	+ 690
Percent over or under capacity	-0.8%	+48.8%	+48.8%	+55.2%
Full-Time Teachers				
Projected Number Required##	92	165	186	194
Deficit###	0	- 62	- 83	- 91

*1974 figures represent existing levels in enrollments and teaching staffs.
**Refer to Appendix C, Table 71 for derivation of projections.
***1974 maximum enrollment capacity total equals 2,120 which includes 1,170 elementary and 950 junior-senior high student enrollment capacities. By 1980, the maximum enrollment capacity total will be 2,595 with an increase in elementary enrollment capacity to 1,345 and junior-senior high enrollment capacity to 1,250.

#Includes figures for rural schools (K-8).
##Based on students to teacher ratio of 20 to 1.
###Based on Fall 1973 level of 103 full-time teachers.

Like Campbell County, the most substantial increase in Converse County enrollments would take place between 1974 and 1980. Enrollments would increase by 78.6 percent from 1,848 to 3,300 students, and existing school enrollment capacities and full-time teacher staffs would not be able to adequately support this increase. By 1980, school enrollments would exceed present capacity levels by 22.7 percent in elementary schools and 32 percent in junior-senior high schools. The school districts would need approximately 60 additional full-time teachers and accommodations for 705 additional students--305 pupils in grades K-6 and 400 junior-senior high school students.

By 1990, the school districts would require a 50-percent increase in present enrollment capacity levels and twice as many existing full-time teachers in order to accommodate the projected enrollment of 3,875 pupils, which include 1,935 elementary and 1,940 junior-senior high school students.

Johnson County. Table 78 in Appendix C, shows the impacts of increasing enrollments on existing school facilities and full-time teacher staffs. Between 1974 and 1980, the Johnson County unified school district would experience a significant 53.2 percent increase in school enrollments from 1,224 to 1,875 students. By 1980, school enrollments would slightly exceed maximum capacity levels by 13.1 percent in elementary schools and only 4.2 percent in junior-senior high schools. The school district would need only one more full-time teacher and additional facilities for 170 more students. After 1980, school enrollments would decrease slightly and, thus, impose no additional requirements upon the school district.

Sheridan, Natrona, Crook, Niobrara, and Weston Counties. Population increases due to coal and energy related developments in the region will

have very minimal, if any, impacts on public education in these counties. Tables 79 through 83 in Appendix C provide the status of existing school facilities and full-time teacher staffs in relation to student enrollment projections for 1980 through 1990. During this time period, school districts in Crook, Niobrara, and Weston Counties will sustain rather stable enrollments. However, if substantial commuting for employment purposes occurs across county lines, particularly from Crook to Campbell County, this prediction could change. Small school districts, like Moorcroft, could have substantial impact from a rather small enrollment increase.

Although the scope of this report does not include the Montana portion of the Powder River Basin, it should be pointed out that school enrollments in Sheridan County would be affected by work force populations associated with coal-energy-related developments in Montana. For the purposes of this report, however, Sheridan County enrollment projections have been based solely on anticipated population changes resulting from developments in Wyoming.

Summary. Table 21 provides a summary of needs for full-time teachers and enrollment capacities to meet projected student enrollment demands for 1980, 1985, and 1990. The combined needs of Campbell and Converse Counties would include the largest share of the region's full-time teacher deficit and enrollment over capacity total. By 1990, the region would require 533 additional teachers and increases in enrollment capacities to accommodate 11,235 additional students. The regional teacher deficit level and enrollment over capacity total would double between 1980 and 1990.

School districts in Campbell and Converse Counties would realize the regions most substantial impacts on existing enrollment capacities and teaching staffs. If these districts do not provide accommodations for increasing enrollments, then the following impacts could result:

Table 21

Summary of Full Time Teacher Deficits and
Enrollments over Existing School District Capacities

School Districts By County	1980 Full Time Teacher Deficit*	1980 Enrollment over Capacity**	1985 Full Time Teacher Deficit*	1985 Enrollment over Capacity**	1990 Full Time Teacher Deficit*	1990 Enrollment over Capacity**
Campbell	201	3,810	366	7,160	426	8,360
Converse	62	705	83	1,130	91	1,280
Crook	-	-	-	-	-	-
Johnson	1	170	-	145	-	145
Natrona	-	750	-	1,100	4	1,450
Niobrara	-	-	-	-	-	-
Sheridan	8	-	10	-	12	-
Weston	-	-	-	-	-	-
Regional Totals	272	5,435	459	9,535	533	11,235

*Full time teacher deficits equal projected demands minus 1973 levels.

**School enrollments are over capacity when student enrollment projections exceed 1975-75 maximum enrollment capacity levels.

1. Classroom sizes would quickly reach capacity and necessitate very high students to teacher ratios;

2. Due to overcrowded conditions and the lack of classrooms in existing school facilities, it may be necessary to use temporary structures such as mobile trailers and modular units;

3. The lack of classrooms and adequate space (gymnasium, play areas) could cause a school district to operate certain schools on a double session basis;

4. Inter-county bussing of students between school districts could result and become necessary; and

5. The quality of education could be affected adversely.

Health and social services

Development of the Eastern Powder River Coal Basin and its attendant population increase will seriously impact several elements of the health and social service systems. Elements already in scarce supply will be most severely impacted.

Health

Existing manpower, facilities, and services will be most impacted by the sheer volume of increase in population.

Manpower. The study area is already short of personnel in virtually all health manpower categories. With the exception of Natrona and Sheridan Counties, the region has few physicians, dentists, nurses (both R.N. and L.P.N.), and optometrists to serve the existing local population. Projected population increases will thus intensify an already serious situation.

Table 22 presents the number of personnel engaged in each of ten health fields for each of the eight counties in the area. Based upon current manpower to population ratios for the State of Wyoming and recommended ratios for the nation as a whole, a set of manpower requirements was estimated for

Table 22

Projected Needed Health Manpower

	Physicians				Dentists				Registered Nurses			
	Existing	Deficiency			Existing	Deficiency			Existing	Deficiency		
	1970	1970	1980	1990	1970	1970	1980	1990	1970	1970	1980	1990
Campbell	7	6-7	25-28	43-48	3	3-5	12-17	21-28	30	15-30	83-121	147-207
Converse	4	2	9-10	11-13	2	1-2	4-6	5-7	24	0-4	22-38	29-47
Johnson, Natrona, Sheridan	96	0	0	0	41	0-5	0-12	0-14	433	0	0	0
Crook, Niobrara, Weston	5	9-10	9-10	9-10	3	3-6	3-6	3-6	45	3-20	3-19	3-19

	Licensed Professional Nurses				Optometrists				Sanitarians**			
	Existing	Deficiency			Existing	Deficiency			Existing	Deficiency		
	1970	1970	1980	1990	1970	1970	1980	1990	1970	1970	1980	1990
Campbell	13	4-8	30-39	54-69	2	0	2-3	4-5				
Converse	5	3-5	12-16	15-20	1	0	1	1				
Johnson, Natrona, Sheridan	157	0	0	0	8	0-3	0-4	3-5				
Crook, Niobrara, Weston	11	7-12	7-12	7-12	2	0	0	0				
Dist. #3*									6	0	0-2	0-3
Natrona									3	0	0	0-2

Table 22 Cont'd

Table 22 Cont'd

	Pharmacists				School Nurses			
	Existing	Deficiency			Existing	Deficiency		
	1970	1970	1980	1990	1970	1970	1980	1990
Campbell	7	4	21	36	5	0	0	3
Converse	5	0	6	8	2	0	0	0
Johnson, Natrona, Sheridan	72	0	1	3	13	0	0	1
Crook, Niobrara, Weston	6	6	5	6	1	1	1	1

	Public Health Nurses				Dental Hygienists			
	Existing	Deficiency			Existing	Deficiency		
	1970	1970	1980	1990	1970	1970	1980	1990
Campbell	2	0	2	4	2	0	0	2
Converse	0	1	2	2	0	0	1	1
Johnson, Natrona, Sheridan	7	2	2	2	12	0	0	0
Crook, Niobrara, Weston	0	2	2	2	0	0	0	0

*Includes all counties but Natrona for sanitation.

**If development includes considerable reliance on mobile homes, particularly in fringe areas, sanitarian requirements will be slightly higher than the upper end of the indicated range.

Source: Wyoming Health Profiles, 1972, Department of Health and Social Services.

Table 22 Cont'd

the period 1980 to 1990. Relying upon the above discussed population projections generated by the University of Wyoming model, manpower requirements are calculated as a function of population. Table 22 presents manpower requirements for each of the eight counties within the region.

Campbell and Converse Counties will be seriously impacted. In 1970 Campbell County had only seven physicians, three dentists, 30 registered nurses, 13 licensed professional nurses, and seven pharmacists. These five manpower categories will be most severely impacted by projected population growth. Likewise, Converse County had only four physicians, two dentists, and five licensed professional nurses. Again, these three areas will be most highly affected by population growth.

Manpower requirements presented in Table 22 are based entirely on population projections. Depending upon local community's ability to provide for the environmental health and safety of new residents, manpower requirements may be somewhat modified. As Table 22 indicates the required number of environmental sanitarians may be greater than that shown. According to the Wyoming Department of Health and Social Services, additional sanatarians will be required in response to uncontrolled development of mobile home parks with inadequate water and sanitation provisions. If such development were to occur, potential hazards to public health and safety would require additional environmental health surveillance.

The remaining six counties in the Powder River Basin region will be less severely impacted. With more gradual population growth, projected manpower requirements can be more readily satisfied. However, here too, existing shortages in the more rural counties may create added difficulties in meeting future needs.

Facilities. The study area currently has an ample supply of health facilites. With few exceptions, the nine hospitals and six nursing care facilities have sufficient capacity to meet present needs.

In projecting future needs, uncertainties as to future utilization rates limited the confidence with which estimates could be generated. The county populations who will be served by health facilities in the area will not necessarily reflect present county utilization patterns. Thus, only regional facility impacts could be calculated. Assuming variations among future county populations will balance out to a level not significantly different from current regional utilization rates, certain regional facility requirements could be calculated. Using the Hill-Burton (78 Stat. 447) formula, approximately 520 and 590 acute beds will be needed in 1980 and 1990, respectively. From the Hill-Harris (84 Stat. 336) formula, approximately 560 and 650 nursing home beds will be needed for these time periods. With a present stock of 495 acute and 557 nursing home beds, the impact of increased bed requirements will not be significant until the 1980-1990 decade.

Services. As with manpower and facilities, services impact will be a direct function of the added demands generated by population growth and the ability of the community to accommodate that growth. Perhaps more than any other service sector, mental health and alcohol treatment will be most sensitive to pressures of rapid development. The effect of such development on the service sector is extremely difficult to predict. The following discussion is thus directed more to general trends than specific points of impact.

Previous periods of rapid development in Campbell County have produced a marked increase in demand for mental health and alcohol treatment

services. Directly related to the stresses produced by rapid development, this past record indicates that if the situation is repeated, the same response is likely to occur. Although a certain amount of variability is due to the predisposing characteristics of the incoming population, the environment into which they come can either intensify or modify these tendencies. Thus, an influx of transient individuals or families, many of whom have pre-existing adjustment difficulties, can create a definite impact on the mental health sector. The degree of impact is, however, a function of the ability of the system to respond to the increased demands placed upon it.

Social services

Based upon past and present conditions generated by rapid mineral related development in such areas as Gillette and Rock Springs, certain general impacts may be noted. The severity of these impacts is, however, dependent upon such variables as the size and composition of the incoming population, the ability of various public service sectors (housing, sanitation, etc.) to accommodate this population, and the psycho-social characteristics which enable these newcomers to adjust to a new and unfamiliar environment.

Population projections indicate that a relatively large proportion of newcomers will be unattached males employed in the construction or mining industries.

These individuals are not expected to seriously affect the present social service system. Rather, the most serious impact is expected from married couples, either with or without children, who are frustrated by inadequate public services, an increasingly high cost of living (as is common to most boom towns), and a lack of effective recreational opportunities. Unless these factors are mitigated and thereby prevented from creating a climate ripe for

dysfunctional behavior, such social services as child protection and family counseling will be severely impacted.

Campbell County, already seriously affected by these factors, illustrates the strain on an existing social service system. Continued rapid development is expected to intensify the situation. Between 1960 and 1970 the population of Campbell County increased by 121 percent. According to estimates of the staff of the Division of Public Assistance and Social Services (1974), the social service caseload increased by at least 150 percent. Although it is impossible to accurately characterize the incoming population, it may be anticipated that if public and recreational services are not adequately supplied and if the newcomers are fairly similar to their predecessors, an increase in social service caseload on the order of previous such increases will be forthcoming. Moreover, this increase will be particularly severe in child protection services.

Converse County, only beginning to experience the effects of rapid development, may be affected in much the same way. Again, the extent of impact will depend upon the same above mentioned factors, and the most serious impact area will probably be child protection services.

Impact on the remaining six counties will depend upon the amount of incoming population and the ability of the existing social structure to assimilate these newcomers into the community. If population increments are relatively small, the community will be far more likely to accomplish this task. The incidence of dysfunctional families will thus be lower, as will the corresponding need for social services.

It should be noted that although the public assistance function will not be seriously affected by rapid mineral-related development, certain isolated impacts may occur. Although the incoming population will generally be well

paid and self-supporting many residents already on public assistance will remain dependent on such support. The typical increase in the cost of living in such rapidly developing areas will impact most severely on those persons who are on fixed, and generally low, incomes. Recipients of public assistance and social security will thus be seriously affected.

Law enforcement

Development of coal and energy related resources with its attendant rise in population will impact the law enforcement personnel and facilities within the region. With a rise in population and immigration of various types of people, crime rates will change to undeterminable new levels. Based on population projections and standard levels of enforcement personnel per 1,000 population, an estimate can be made of the number of enforcement personnel which would likely be required to provide adequate law enforcement. These projections can be compared to the existing situation, thereby providing some measure of the magnitude of impact.

Sheriff departments

Table 23 presents the full-time manpower projections that would be required for sheriff's departments to meet the increased demand. In the region, Campbell and Converse County sheriff departments will require the most sizeable increases in manpower. At present, sheriff agencies in the remaining six counties (except Sheridan) have reasonably adequate full-time staffs and probably would require minimal, if any, changes to meet the demand by 1990. The major increase in demand occurs in the period from the present time to 1980. The projections indicate that to serve the increased population by 1980, a total of 74 new law enforcement personnel would be required. From 1980 to 1985, the number of personnel required would increase by 17, and

Table 23

Projections for Full Time Manpower* of
Sheriff's Departments in Powder River Basin

	1973	Projections 1980		1985		1990	
	Actual	Need**	Deficit***	Need**	Deficit***	Need**	Deficit***
Campbell	8	32	24	46	38	50	42
Converse	6	13	7	15	9	15	9
Crook	5	5	0	5	0	5	0
Johnson	3	7	4	7	4	7	4
Natrona	37	59	22	60	23	62	25
Niobrara	2	3	1	3	1	3	1
Sheridan	4	18	14	18	14	18	14
Weston	4	6	2	6	2	6	2
Region Total	69	143	74	160	91	166	97

*Full time employees include both sworn officers and civilians.

**The state average is 0.6 full time employees per 1,000 population. The national average is 1.0 full time employees per 1,000 population. For the purposes of this report, the national average is used to determine demand levels.

***Deficit based on actual manpower in 1973.

from 1985 to 1990 the increase drops off to six. As population is expected to stabilize beyond 1990, the demand for enforcement personnel is not expected to experience any rapid rise.

The Wyoming State Highway Patrol will also be impacted. Increased traffic flow would in all probability necessitate a corresponding increase of patrol personnel. However, it is difficult to determine how much of an increase may be required to provide an adequate level of service and coverage. Most of the law enforcement burden would be borne by local and county agencies.

Campbell County Sheriff's Department. By 1980, the existing manpower will be unable to provide adequate service and coverage due to a rapidly increasing county population. As indicated in Table 23, the departmental staff will require a 525 percent increase from eight full-time employees in 1973 to 50 employees by 1990. The most critical growth period will occur between 1974 and 1980, when the department, to meet the demand, would need to increase its present staff 24 full-time employees in conjunction with the county's 148.5 percent increase in population.

Converse County Sheriff's Department. In order to provide adequate service and coverage for an increasing population in the county, the sheriff's department would require a 159 percent increase from six full-time employees in 1973 to at least 15 employees by 1990 (Table 23). The departmental staff would be overextended by 1980 and would require seven additional staff members.

Municipal police departments

Tables 84 through 93 in Appendix C indicate the projected manpower that would be required for full-time policemen, office facilities,

and patrol vehicles for each municipal police department. Table 24 provides a summary of these needs for the region.

The needs for jail and correctional facilities have not been projected because of the lack of an acceptable criterion. The Law Enforcement Assistance Administration (U.S. Department of Justice) and local agencies could not provide or predict jail facility requirements per community population but indicated that existing facilities may require expansion if populations increase significantly. The capacity of jails is somewhat dependent on a number of crime factors.

Gillette Police Department. Table 84 in Appendix C provides a detailed assessment of projected police needs for Gillette. Basically, in order to provide an increasing city population with adequate police service and protection, the police department would need to grow 200 percent from 16 full-time policemen in 1973 to 47 officers by 1990. This substantial increase in staff size also would require 11 more patrol cars and an additional 1,250 square feet of office space.

By 1980, the existing police force would be overextended without an additional 14 full-time officers and five more patrol cars. Existing office facilities would be adequate until 1985, when an additional 800 square feet would be needed if the force were increased to meet the demand.

Douglas Police Department. A detailed assessment of projected police needs for Douglas is presented in Table 85 in Appendix C. Between 1973 and 1990, the police force would need to expand its existing staff size by 133 percent from six to 14 full-time policemen to meet the demand. To support this increase in manpower, the department would require an additional two patrol cars and 400 more square feet of office space.

Table 24

Summary of Deficits in Full Time Manpower, Office Space and Patrol Vehicles of Municipal Police Departments

Police Departments	1980 Deficits* Full Time Manpower	1980 Deficits* Office Sq.Ft.	1980 Deficits* Patrol Vehicles	1985 Deficits* Full Time Manpower	1985 Deficits* Office Sq.Ft.	1985 Deficits* Patrol Vehicles	1990 Deficits* Full Time Manpower	1990 Deficits* Office Sq.Ft.	1990 Deficits* Patrol Vehicles
Gillette	14	-	5	27	800	9	31	1,250	11
Douglas	5	200	1	6	300	1	7	400	2
Glenrock	2	300	1	3	400	2	3	400	2
Buffalo	3	770	1	3	770	1	3	770	1
Sheridan	2	-	1	2	-	1	2	-	1
Casper	21	-	10	23	-	10	25	-	10
Mills	2	300	-	2	300	-	2	300	-
Newcastle	0	200	-	0	200	-	0	200	-
Sundance	1	-	-	1	-	-	1	-	-
Lusk	-	-	-	-	-	-	-	-	-
Totals	50	1,770	19	67	2,770	24	74	3,320	27

*Deficits equal projected demands minus existing (1973) levels.

In order to accommodate the city's largest population increase between 1974 and 1980, the police department would need to double its existing full-time officer staff and acquire one more patrol car and an additional 200 square feet of office space.

Glenrock Police Department. As indicated in Table 86 in Appendix C, the department would need an additional three full-time policemen, two patrol cars and 400 square feet of office space by 1990 to meet the demand. The most substantial demand increases occur between 1974 and 1980, when the department would require an additional two full-time officers, 300 square feet of office space, and a patrol car.

Buffalo, Sheridan, and Casper Police Departments. The needs of these three departments to meet projected demands are indicated in Appendix C (Tables 87 through 89). By 1980, Buffalo would lack three full-time policemen, one patrol vehicle, and adequate office space; Sheridan would require an increase of two officers and one patrol vehicle; and Casper would lack 21 policemen and ten vehicles. If 1980 demand levels are met, Sheridan and Buffalo police departments would require no additional increases between 1980 and 1990. However, by 1990, Casper would need to increase its 1980 manpower demand level by four full-time officers.

Mills, Lusk, Newcastle, and Sundance Police Departments. Appendix C (Tables 90 through 93) describes the needs of these departments. At current levels, Newcastle, Lusk, and Sundance would have an adequate number of policemen and patrol vehicles to meet projected demands in the 1980 to 1990 period.

Municipal police department summary. Table 24 provides a summary of projected needs to meet the demand for 1980, 1985, and 1990. The major deficits occur between now and 1980 when a total of 50 officers, 1,770 square feet

of office space and 19 vehicles would be required to meet the demand on these departments by an expanded population.

Crime levels

In the description of the existing environment section of this report, the current levels of crime incidence are fully described for each county in the region. However, crime is a social problem that is not only difficult but nearly impossible to project in the future, especially in areas which will realize large immigration and rapid population increases. The Federal Bureau of Investigation (FBI) in its latest Uniform Crime Report states that factors which cause crime are many and vary from place to place. The FBI cautions against comparing statistical information of individual communities solely based on a similarity in their population counts.

Population is only one of many factors which must be considered. Some of the conditions or crime factors which affect the volume and type of crime that occurs from place to place are briefly outlined as follows (FBI 1973, p. vii):

--Density and size of the community population and metropolitan area of which it is a part.

--Composition of the population with reference particularly to age, sex and race.

--Economic status and morals of the population.

--Stability of population, including commuters, seasonal and other transient types.

--Climate, including seasonal weather conditions.

--Education, recreational and religious characteristics.

--Effective strength of the police force.

--Standards of appointments to the local police force.

--Policies of the prosecuting officials.

--Attitudes and policies of the courts and corrections.

--Relationships and attitudes of law enforcement and the community.

--Administrative and investigative efficiency of law enforcement.

--Including degree of adherence to crime reporting standards.

--Organization and cooperation of adjoining and overlapping police jurisdictions.

Since there is no way of predicting the socio-economic and personality profiles of incoming populations in the 1974-1990 time frame, the levels and types of crime incidence will remain largely unknown. Thus, the crime rate will change to indeterminable new levels, and this potential change in crime incidence will be an impact on the region as a whole.

Law enforcement agencies in Campbell and Converse Counties will require the largest increases in full-time staff sizes, facilities, and police vehicles. If the projected needs of these agencies are not met, the counties and local communities would not have adequate police services and proper coverage. While the presence of more police officers does not necessarily prevent crime or any increases, police officers are needed to arrest crime. Thus, a law enforcement agency with significantly large shortages in manpower may not be able to adequately respond to and investigate incidences as they occur. Under these conditions, increasing crime rates could impact a wider portion of the population.

Fire protection

From the National Fire Underwriters the recommended fire department strength of a city is based on the individual town's required fire flow. Estimated fire flow is based on a rather complicated formula involving a town's building composition and size. The number and location of fire houses is dependent on the distribution and shape of a town. In the absence of ability

to predict a growing town's building composition, Table 94 (Appendix C) provides a means of estimating fire flow on the basis of population. Once fire flow is estimated, Table 95 (Appendix C) can be used to establish the equipment necessary for the fire department.

Table 44, Appendix C, projects urban population increases for the Cities of Douglas and Gillette. Based on these forecasts, the impact and deficiency of existing facilities can be evaluated.

Douglas is projected for rather dramatic population increases by 1980 and 1990 that will increase its fire flow requirements from its presently less than 2,000 gpm (gallons per minute) to 2,500 gpm by 1980. Existing pumping units fail to meet this higher fire flow requirement and leave a deficiency of 1,500 gpm. Twenty volunteer firemen appear inadequate to meet a larger town's needs.

Gillette, even more than Douglas, is faced with tremendous population growth which will increase its existing fire flow requirements of 2,500 gpm to about 4,000 gpm by 1980 and about 5,000 gpm by 1990. Their present pumper truck capacity is already deficient by 750 gpm. By 1980, it is estimated that the community will need two pumper trucks with 2,250 gpm combined capacity and a ladder truck. By 1990, an additional pumper of 1,000 gpm capacity will be needed, plus another ladder truck. An additional fire house and full-time fire crew will likely be required.

Summary

Table 25 summarizes the estimated fire flow requirements of Douglas and Gillette.

Table 25

Fire Flow Requirements for Douglas and Gillette

	1974	1980		1985		1990	
Town	Capacity	Estimated Need	Deficiency	Estimated Need	Deficiency	Estimated Need	Deficiency
Douglas	1,000 gpm	2,500	-1,500	2,500	-1,500	2,500	-1,500
Gillette	1,750 gpm	4,000	-2,250	4,500	-2,750	5,000	-3,250

The net impact of having deficiencies of pumping capacity by these communities is that more damage could be sustained to burning buildings because of an inability to pump enough water onto larger fires. In the case of simultaneous fires in different parts of the city, the fire department may be spread too thin to provide adequate protection at either fire. The probability of larger and more damaging fires is thus increased. Potential loss of human life due to fire is also increased.

Water and sewer facilities

Nearly 80 percent of the growth induced by coal and other industrial development will occur in Campbell and Converse Counties and principally in the Cities of Gillette and Douglas; additional population will impact the capacity of the present water and sewer facilities.

Water

Gillette. Current and estimated water demands (Table 26) range from 1.3 million gallons per day (gpd) in 1970 to an anticipated 3.2 million gpd by 1980 and 5.0 million gpd by 1990[1] The water supply will be more than

[1] Wyoming State Engineer's office uses 180 gallons per day for per capita daily water usage as its standard for planning. Intermountain Planners and Wirth-Berger Associates (IPWBA), Ch. II, B.

6.1 million gpd by 1990 which will be more than sufficient to meet predicted 1990 demand (Intermountain Planners and Wirth-Berger Associates (IPWBA), Ch. IV). On the other hand, if the city's contract with the company building a power plant and a coal gasification plant to supply 3,500 acre-feet per year beginning in 1977 is not realized, the water supply will reach capacity between 1975 and 1980 (IPWBA, Ch. IV). The water treatment facility presently is inadequate to process a peak day demand for water.[1] The capacity of the water treatment plant is 2.2 million gpd and was 1.5 million gpd below the greatest level of service in 1970 and will be 7.0 million gpd and 12.2 million gpd below recommended capacity by 1980 and 1990, respectively.[2] The water distribution system is fully utilized at present; however, the distribution system will be insufficient by 1980 and 1990 by 6.5 million gpd and 10.8 million gpd ,respectively. The added population to the city of Gillette will place such water demands on existing facilities that expansion of the physical plant would be required by 1980 and 1990.

Douglas. Current and estimated water demand (Table 26) range from 0.5 million gpd in 1970 to an anticipated 1.1 million gpd by 1980 and 1.3 million gpd by 1990. The water supply will be over 3.0 million gpd by 1990 which will be more than sufficient to meet predicted 1990 demand. The capacity of the water treatment plant is 1.4 million gpd which is presently fully utilized and will be 1.7 million gpd and 2.2 million gpd below projected service levels by 1980 and 1990, respectively. The water distribution system is

[1]Peak water usage is generally 2.5 times the average daily use or 450 gpd per capita. IPWBA, Ch. II, B.

[2]Water treatment plants should be able to process a peak day's usage plus 15% excess capacity. IPWBA, Ch. II, B.

		1970	1980	1990
WATER TREATMENT*				
Gillette:	Demand**	3,700,000 gpd##	9,200,000 gpd	14,500,000 gpd
	Present Capacity***	2,200,000 gpd	2,200,000 gpd	2,200,000 gpd
	Capacity Excess (+)# or Deficit (-)	- 1,500,000 gpd	-7,000,000 gpd	-12,200,000 gpd
Douglas:	Demand**	1,400,000 gpd	3,100,000 gpd	3,600,000 gpd
	Present Capacity***	1,400,000 gpd	1,400,000 gpd	1,400,000 gpd
	Capacity Excess (+)# or Deficit (-)	0 gpd	-1,700,000 gpd	-2,200,000 gpd
WATER DISTRIBUTION				
Gillette:	Demand**	3,700,000 gpd	9,200,000 gpd	14,500,000 gpd
	Present Capacity***	3,700,000 gpd	3,700,000 gpd	3,700,000 gpd
	Capacity Excess (+)# or Deficit (-)	0 gpd	-6,500,000 gpd	-10,800,000 gpd
Douglas:	Demand**	1,400,000 gpd	3,100,000 gpd	3,600,000 gpd
	Present Capacity***	1,400,000 gpd	1,400,000 gpd	1,400,000 gpd
	Capacity Excess (+)# or Deficit (-)	0 gpd	- 700,000 gpd	-2,200,000 gpd

*All calculations rounded to the nearest 100,000.
**Water treatment and distribution demand is 15 percent in excess of the product of peak water usage (450 gpd per capita) and total population. Intermountain Planners, Billings, Montana and Wirth-Berger Associates, Denver, Colorado (IPWBA) Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development (hereafter referred to as Capital Facilities Study), Chapter II-Public Facilities Demand and Cost, Section B - Demand for Services and Facilities, Water.
***IPWBA, Capital Facilities Study, Chapter I - Inventory of Public Facilities, Douglas and Gillette.
#Difference between demand and present capacity.
##gpd is abbreviated for gallons per day.

Table 26
Current and Projected Water Demands
for Douglas and Gillette, Wyoming 1970-1990

also fully utilized at present. The distribution system based on present levels will be insufficient to serve future demands by 0.7 million gpd in 1980 and 2.2 million gpd in 1990. Similar to Gillette, Douglas will need to expand existing facilities to satisfy the water demands of an increased population.

Sewer collection and treatment

Gillette. Sewer collection and treatment systems will need to expand to satisfy future populations from a 1970 demand of 1.2 million gpd to a 1980 demand of 3.0 million gpd and a 1990 demand of 4.7 million gpd[1] (Table 27). The present capacity of the sewer treatment plant is 1.4 million gpd. At present the sewer collection system is at two-thirds capacity. If no additions were made to the collection system, the system would reach capacity between 1975 and 1980. Assuming no expansion occurs, the collection system would be incapable of serving 1980 and 1990 projected demands by 1.2 million gpd and 2.9 million gpd, respectively. Although average daily usage in Gillette is less than the state average, Wyoming state standards were used for analytical purposes. The existing treatment plant is sufficient to more than meet current demand levels; however, population growth will place additional demands such that the facility will be deficient by 1.6 million gpd in 1980 and 3.3 million gpd in 1990. Present facilities must expand to meet the sewer demands of a growing population.

Douglas. Sewer collection and treatment systems will need to expand to satisfy the future populations from a 1970 demand of nearly 0.5 million gpd to a 1980 demand of 1.0 million gpd and a 1990 demand of 1.2 million gpd (Table 27). Capacity of the water treatment and collection system

[1]Maximum daily flow would be about 168 gallons per capita, IPWBA, Ch. II, B.

		1970	1980	1990
WASTE WATER COLLECTION*				
Gillette:	Demand**	1,200,000 gpd##	3,000,000 gpd	4,700,000 gpd
	Present Capacity***	1,800,000 gpd	1,800,000 gpd	1,800,000 gpd
	Capacity Excess (+)# or Deficit (-)	+ 600,000 gpd	-1,200,000 gpd	-2,900,000 gpd
Douglas:	Demand**	500,000 gpd	1,000,000 gpd	1,200,000 gpd
	Present Capacity***	500,000 gpd	500,000 gpd	500,000 gpd
	Capacity Excess (+)# or Deficit (-)	0 gpd	- 500,000 gpd	- 700,000 gpd
WASTE WATER TREATMENT*				
Gillette:	Demand**	1,200,000 gpd	3,000,000 gpd	4,700,000 gpd
	Present Capacity***	1,400,000 gpd	1,400,000 gpd	1,400,000 gpd
	Capacity Excess (+)# or Deficit (-)	+2,000,000 gpd	-1,600,000 gpd	-3,300,000 gpd
Douglas:	Demand**	500,000 gpd	1,000,000 gpd	1,200,000 gpd
	Present Capacity***	500,000 gpd	500,000 gpd	500,000 gpd
	Capacity Excess (+)# or Deficit (-)	0 gpd	- 500,000 gpd	- 700,000 gpd

*All calculations rounded to the nearest 100,000.
**Waste Water Collection and Demand is the product of the maximum expected daily flow (168 gallons per capita) and total population. Intermountain Planners, Billings, Montana and Wirth-Berger Associates, Denver, Colorado (IPWBA) Powder River Capital Facilities Study for the Wyoming Department of Economic Planning and Development (hereafter referred to as Capital Facilities Study), Chapter II - Public Facilities Demand and Cost, Section B-Demand for Services and Facilities, Sewer.
***IPWBA, Capital Facilities Study, Chapter I - Inventory of Public Facilities, Douglas and Gillette.
#Difference between demand and present capacity.
##gpd is abbreviated for gallons per day.

Table 27
Current and Projected Sewer Demands for
Douglas and Gillette

is about 0.5 million gpd. While current sewage demands are satisfied, the present systems are inadequate to accommodate anticipated increased demands. Both the present waste water collection and treatment facilities will be deficient by 0.5 million gpd by 1980 and 0.7 million gpd in 1990. Present facilities must expand to meet the sewer demands of a growing population.

Summary

If water and sewer facilities are not expanded in a timely fashion to meet the demands of an expanding population significant secondary impacts could occur. If water is not treated properly serious health hazards could develop. Use of a poor quality water could result in a higher incidence of disease and possibly to epidemics of major diseases.

Overuse of the sewage facilities could result in more sewage being dumped into stream channels, such as Donkey Creek and eventually into the North Platte River. This would lower water quality and impact fish and wildlife populations. The polluted water could also act as the source of diseases, especially if ground water aquifers become polluted.

Utilities

Although most utility companies contacted felt their system could adequately handle increased consumer demand from the projected population increases and could respond to consumer service requests in a timely fashion, exceptions were noted. One natural gas company was unsure as to its ability to provide service to new customers because its supplier advised them that quantities of fuel in addition to their present quota might not be forthcoming. The local distributor could add no further specifics to this warning.

The utility companies are experiencing long delays in the acquisition of certain construction materials. There is likely potential pipe

shortage and some major equipment items such as pole transformers are taking up to 50 weeks to acquire. The companies are planning and ordering supplies further in advance to resolve this problem.

The telephone company in Douglas felt it could handle new orders for telephone service unless the direction in which the town grew was to the north where adequate tie-in service was not available. Also, if a coal gasification plant were to locate near Douglas, service to some new residential areas could possibly be delayed up to six months regardless of where they located because of the massive number of new employees required for this type of plant.

Most of the utility companies would have to hire additional crews if faced with a very sudden increase in demand as in the case of Douglas and a coal gasification plant.

Other than the instances cited above, none of the utility companies expected that demand on their facilities would induce shortages of service or conditions that may curtail service (brownouts, rationing, etc.). Electrical shortages in this area are not likely. It is not possible to identify a point when saturation of their facilities might occur to require a cutback in service. Facility expansion is presently a continual process in this area and their ability to react to fluctuations appears good. As a rule, the companies are anticipating increased consumer demand due to sudden population increases and are planning and engineering the needed improvements.

Community attitudes and life styles

Community attitudes cannot be predicted with any accuracy. The multitude of economic, social, and psychological (among other) variables which come together in the unique combinations known as community attitudes are

difficult enough to assess at a given point in time. Following the introduction of a new element into the community system, attitude assessment becomes an impossible task.

The impact of development on prevailing life styles will depend upon the magnitude and speed of population growth, the degree to which public services can accommodate that growth, and the ability and desire of incoming persons to establish ties in the community.

In Campbell County the prevailing ranching lifestyle fell before the onslaught of a sudden population influx which could not be accommodated by existing public services. In addition, although many of the new residents did establish strong community ties, many did not. Faced with another period of rapid development, present difficulties in defining a new lifestyle will be aggravated. Efforts to provide for the needs of the last population influx have succeeded in reducing the severity of the present situation.

In Converse County, ranching remains the dominant lifestyle. However, with population increases expected to more than double the population between 1970 and 1980, ranching will lose much of its dominance. Economically, mineral related employment will gain dominance. While ranching may shift in economic importance, social importance will depend upon community preparedness. If public services are adequately and plentifully supplied, assimilation is far more likely to occur. Although the speed and magnitude of population growth suggests that assimilation will be incomplete, the ranching lifestyle will remain more visible than if amalgamation were to occur.

Since lifestyle impact is a direct function of population growth, of the six remaining counties in the area, only Johnson County should be strongly affected. With a projected 50 percent population increase between 1970 and 1980, Johnson County may be severely enough impacted to experience lifestyle stress.

CHAPTER VI

SIGNIFICANT MITIGATING MEASURES

This chapter summarizes authorities, both in law and regulation, that will mitigate possible adverse effects of coal and industrial development in the Eastern Powder River Coal Basin. Technological treatments available are discussed in Parts II through VII of this statement along with the consideration of specific actions.

Climate

Since potential weather modification is closely related to air quality standards and resource disturbance, more detailed information concerning mitigating measures are contained within these chapters. The utilization of emissions control equipment on vehicles, plant stacks, dust control measures and timely revegetation of mined lands will reduce particulate matter available to the atmosphere and reduce the effects on weather from alteration of the earth atmospheric energy balance.

Air Quality

The enforcement of all applicable federal and state laws and regulations concerning air quality standards for control of emissions will reduce the cumulative effects on air quality of regional development. These include:

1. Federal Clean Air Act, as amended in 1970;
2. National Ambient Air Quality Standards;
3. New Source Performance Standards (NSPS);
4. National Emission Standards for Hazardous Air Pollutants;
5. Wyoming Environmental Quality Act of 1973; and
6. Wyoming Ambient Air Quality Regulations.

Development and utilization of reliable emission control equipment on existing and new equipment, vehicles and plant stacks will reduce the cumulative amount of pollutants entering the regional atmosphere.

Air quality standards

National Ambient Air Quality Standards (NAAQS) for suspended particulate matter, sulfur oxides, nitrogen oxides, photochemical oxidants, carbon monoxide, and hydrocarbons were promulgated by the Environmental Protection Agency (EPA) on April 30, 1971, under provisions of the Clean Air Act, as amended in 1970. Table 1 lists these standards. It is the responsibility of the Wyoming Department of Environmental Quality to insure that these standards are attained and maintained. If the state does not carry out this responsibility, EPA must take action to enforce the standards. Primary standards are health related and, in most cases, must be achieved by July 1975. Secondary standards are welfare related (material, vegetation, visibility, etc.) and must be achieved as expeditiously as possible. In rural areas this may mean July 1975, whereas in urban areas it may mean well beyond July 1977.

Wyoming ambient air quality standards were promulgated in accordance with the Wyoming Environmental Quality Act of 1973. Under Article 2 of the Act the Wyoming Department of Environmental Quality, Air Quality Division, is empowered to enforce standards. Table 2 contains the Wyoming ambient air quality standards. Wyoming has also adopted emission regulations; these standards are shown in Table 3.

Any new fossil fuel-fired steam generators or modification to existing plants must conform to the New Source Performance Standards (NSPS). Table 4 lists these standards.

Table 1

National Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
1. Sulfur Oxides	80 ug/m^3 (0.03 ppm) annual arith. mean 365 ug/m^3 (0.14 ppm) max. 24 hr. conc. not to be exceeded more than once a year.	1300 ug/m^3 (0.5 ppm) max. 3 hr. conc. not to be exceeded more than once a year.
2. Particulate Matter	75 ug/m^3 annual geom. mean 260 ug/m^3 max. 24 hr. conc. not to be exceeded more than once a year.	60 ug/m^3 annual geom. mean*, 150 ug/m^3 max. 24 hr. conc. not to be exceeded more than once a year.
3. Carbon Monoxide	10,000 ug/m^3 (9 ppm) max. 8 hr. conc. not to be exceeded more than once a year.	Same as primary.
	40,000 ug/m^3 (35 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.
4. Photo Chemical Oxidants (corrected for NO_2 and SO_2 interference.	160 ug/m^3 (0.08 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.
5. Hydrocarbons (corrected for CH_4)	160 ug/m^3 (0.24 ppm) max. 3 hr. conc. (6 to 9 a.m.) not to be exceeded more than once a year.	Same as primary.
6. Nitrogen Oxides (as Nitrogen Dioxide)	100 ug/m^3 (0.05 ppm) annual arith. mean.	Same as primary.

*To be used as guide in assessing State Implementation Plans.

Table 2

Wyoming Ambient Air Quality Standards

Pollutant	Standard						
	Annual	Month	24-hour	8-hour	3-hour	1-hour	1/2 hour
Particulate, ug/m^3	60 G.M.	-	150**	-	-	-	-
, COH/1000 feet	0.4	-	-	-	-	-	-
SO_2, ug/m^3	60	-	260**	-	1.300**	-	-
, sulfation mg $SO_3/100\ cm^2/day$	0.25	0.50	-	-	-	-	-
CO, mg/m^3	-	-	-	10**	-	40**	-
NO_x, ug/m^3	100 A.M.	-	-	-	-	-	-
HC, ug/m^3	-	-	-	-	160**	-	-
Oxidants, ug/m^3	-	-	-	-	-	160**	-
HF, total, ppb	-	-	1	-	-	-	-
HF, forage - ppmw	25	-	-	-	-	-	-
HF, gaseous - ug/cm^2	-	0.3	-	-	-	-	-
H_2S, ug/m^3	-	-	-	-	-	-	40* twice/ 5 days 70* twice/ year

*Not to be exceeded more than
**Not to be exceeded more than once per year

Table 3

Wyoming Emission Standards

A. Fuel Combustion - Particulate Matter

10^6 Btu/hr. Fuel Heat Input*	# Particulate/10^6 Btu Existing Source	New Source**
10	0.6	0.10
10,000	0.18	0.10

B. Fuel Combustion - NO_x

Fuel Fired	# $NO_x/10^6$ Btu Existing Source	New Source**
Gas	0.23	0.2
Oil	0.46	0.3

C. Visible Emissions

Existing Source	40 percent opacity
New Source**	20 percent opacity

*Interpolate between values
**After February 22, 1972

Table 4

NSPS for Steam Generators

	Allowable Emissions Fuel-Fired Coal	Oil	Gas
Particulate, #/10^6 Btu	0.10	0.10	0.10
Particulate, opacity	20%	20%	20%
Sulfur dioxide, #/10^6 Btu	1.20	0.80	--
Nitrogen oxides, #/10^6 Btu	0.70	0.30	0.20

Water Quality and Supply

National standards to restore and maintain the chemical, physical and biological integrity of the nation's waters were promulgated by the Federal Water Pollution Control Act (FWPCA) as amended in 1972, and as it may be hereafter amended.

Wyoming water quality standards were issued in accordance with the Wyoming Environmental Quality Act of 1973. Under Article 3 of the Act, the Wyoming Department of Environmental Quality, Water Quality Division, is empowered to enforce these water quality standards. Important prescribed standards include those which specify maximum short-term and long-term concentrations of pollution, minimum permissible concentrations of dissolved oxygen and other matter, and the permissible temperatures of the waters of the state. Effluent standards and limitations specifying the maximum amounts of pollution and waste which may be discharged into state waters are described. Other health and water quality standards pursuant to section 402(b) of the FWPCA, as amended in 1972, are described as well.

The enforcement of all applicable federal and state laws and regulations concerning water quality standards will reduce the cumulative effects of regional development on water quality. These include:

1. Federal Water Pollution Control Act, as amended in 1972, and as it may be hereafter amended;
2. Wyoming Environmental Quality Act of 1973; and
3. Water Quality Standard for Wyoming, Wyoming Department of Health and Social Services, State of Wyoming, June 28, 1973.

Water supplies

Wyoming water law requires water-right filings for water impoundments and for the general utilization of water from ground- or surface-water sources. If the mining activity interfers with existing ground- or surface-water rights, it may be required that water be provided to satisfy these rights.

Provisions under Wyoming water law make it possible to change the location of a well, a reservoir or irrigated lands that are affected by activities such as mining. This would prevent the loss of these facilities and of irrigated lands, and in many instances would reduce the impact of the mining activity.

The appropriation of and supervision and distribution of ground and surface water is under control of the office of State Engineer and the Board of Control.

Monitoring programs

Monitoring programs are being established by companies planning to mine coal. A number of the monitoring programs are being planned in consultation with the Water Resources Division of the U.S. Geological Survey. The programs consist of establishing observation wells to determine water level fluctuations in the coal and the overlying overburden in the mine lease areas. Water samples are being collected to determine the chemical quality of the water and to serve as a basis for detecting changes in water quality after mining begins. As mining of coal progresses, additional observation wells will be established in or near backfill areas to monitor for leaching of toxic materials from the backfill and movement of the water from the backfill areas.

Resource Disturbance

Federal

Significant disturbances to the natural and human environment are associated with surface mining and railroad, transmission, pipeline and road construction. Unless measures to mitigate impacts are initiated timely after disturbance occurs, productive capacity of the affected areas may be lowered and other adverse effects realized. Listed below are some of the laws and regulations which grant the Secretaries of Interior and Agriculture and the Commissioner of the Interstate Commerce Commission authority to impose measures that will mitigate adverse impacts on the natural and human environment:

1. Mineral Leasing Act (41 Stat. 437 as amended; 30 U.S.C. 181 et seq);
2. Mineral Leasing Act for Acquired Lands (61 Stat. 913; 30 U.S.C. 351-359);
3. Multiple Use-Sustained Yield Act of 1960 (74 Stat. 215; 16 U.S.C. 528-531);
4. Bankhead-Jones Farm Tenant Act of July 22, 1937 (50 Stat. 525; 7 U.S.C. 1010-1012);
5. Interstate Commerce Act (49 Stat. 543; 49 U.S.C. 1(18));
6. Title 43 CFR Parts 23 and 3500;
7. Title 43 CFR Subpart 3501;
8. Title 30 CFR Part 211; and
9. Title 36 CFR Part 213.

Mitigating measures with respect to development of coal are found in the Mineral Leasing Act of 1920, as amended. The lessee has the obligation to report quarterly on the amount and character of extracted leased coal, make quarterly royalty and

annual lease payments, and protect and rehabilitate the surface. The Mineral Leasing Act for Acquired Lands authorized the leasing of mineral deposits, with the consent of the agency having jurisdiction over the lands, in lands acquired by the United States to which the "mineral leasing laws" have not been extended. In addition, the mine operator is subject to the supervision and administration of the Department of Interior through the Geological Survey in conjunction with the agency having administrative jurisdiction of the surface. The lessee must comply with CFR Part 211, Coal Mining Operating Regulations. These coal operating regulations were revised and published in the Federal Register as proposed rules on April 30, 1973. These regulations will govern operations for discovery, testing, development, mining and preparation of coal under leases, licenses and permits issued on public domain and acquired lands pursuant to the regulations in 43 CFR Group 3500. The purpose of the regulations in Part 211 is to promote orderly and efficient operations and production practices without waste or avoidable loss of coal or other mineral bearing formation; to encourage maximum recovery and use of coal resources; to promote operating practices which will avoid, minimize, or correct damage to the environment, including land, water, and air, and avoid, minimize, or correct hazards to public health and safety; and to obtain a proper record of all coal produced.

Bonding

Title 43 Code of Federal Regulations, Part 23.9 states: "Upon approval of an exploration plan or mining plan, the operator shall be required to file a suitable performance bond of not less than $2,000. . . . The Bond shall be in an amount sufficient to satisfy the reclamation requirements of an approved exploration or mining plan, or an approved partial or

supplemental plan. In determining the amount of the bond, consideration shall be given to the character and nature of the reclamation requirements and estimated costs of reclamation in the event that the operator forfeits his performance bond."

Deposits of cash or negotiable bonds may be used in lieu of surety bonds. An operator may file a nationwide or statewide lease surety bond with the Bureau of Land Management to cover reclamation requirements under more than one lease if its terms and conditions are sufficient to comply with the regulations in 43 CFR Part 23. The amount of bond required to cover each lease is established by the BLM district manager after consultation with the Geological Survey mining supervisor, and when appropriate with other land management agencies if involved.

43 CFR 23.9 was issued January 18, 1969, and its requirements have been incorporated in all coal leases issued by BLM since that date.

Most coal leases issued by BLM prior to January 1969 were issued on a lease form similar to the current coal lease form (Form 3130-1), which states in Sec. 2, that the lessee agrees "to maintain the bond furnished upon the issuance of this lease, which bond is conditioned upon compliance with all provisions of the lease, and to increase the amount or furnish such other bond as may be required." A nationwide or statewide bond may also be used in lieu of the bond required by this section.

Such a bond covers compliance with Sec. 5 of the lease, titled "protection of the surface, natural resources and improvements." The amount of bond required under either provision may be adjusted to cover the estimated cost of compliance, at any given time, with the lease terms and terms of any approved mining and reclamation plans.

Wyoming

Wyoming's Environmental Quality Act of 1973 created the Department of Environmental Quality and vested in that agency broad powers to oversee and enforce mined land restoration and reclamation in the state. In addition to establishing rules and regulations DEQ also grants permits and licenses to mine or explore for minerals; invokes penalties for non compliance; requires and collects performance bonds; and can reclaim mined land if bonds are forfeited. Written consent or waiver by the surface owner is required before a mining permit can be granted.

Proposed land quality regulations are in the public hearing stage and should soon be issued in final form. However, under terms of the Act, minimum reclamation standards require restoration of land to equal or higher value; revegetation of mined lands; stockpiling and reuse of topsoil; and prevention of erosion, land slides, sedimentation and water pollution. Upon conclusion of reclamation, up to 75 percent of the bond may be returned to the operator. The remaining 25 percent, and not less than $10,000, is held for five years to insure proper revegetation. This also may be returned on consent of the landowner and the DEQ.

Violation of the Act or regulations can result in penalties up to $10,000 per day for non-willful violations. The penalty for willful violations is up to $25,000 per day and/or up to a year in prison. Penalty limits double for second offenses.

Surface protection and rehabilitation

Each mining operation, road, pipeline, powerline, railroad or other action that would cause surface disturbance is unique, having different construction and operating requirements. Surface disturbing activities vary from casual occupation of the surface such as off-road vehicle use to complete disruption of the land surface and underlying strata. In addition, these activities normally occur through time and over areas with differences in climate, topography, soils and vegetation.

Preplanning--land use objectives

In view of all the variations that will be encountered, preplanning is necessary to assure successful surface protection and land rehabilitation. A determination must be made in the preplanning stage of the use to which land might be committed after mining and reclamation, and consideration given to the site suitability and capability to respond to rehabilitation.

Land use objectives should be selected and decided upon before mining. Objectives should be compatible with controlling physical conditions such as climate, soils and local topography and must be realistically attainable.

In order to preplan rehabilitation and determine land use objectives, an assessment is needed of overburden, its physical and chemical characteristics. Topography, hydrology, mining methods and equipment, access roads, road grades, transportation systems, pit limits, stripping ratio of overburden to coal, production rates, and bench heights must also be considered.

In general, the mining and reclamation plan filed with the U.S. Geological Survey, in conjunction with federal regulations, state laws, and the coal lease terms, requires actions to mitigate adverse effects of surface mining. The restored landform will be determined by consultations among the operator, the agency having jurisdiction over the surface, the Wyoming Department of Environmental Quality and the U.S. Geological Survey. Such consultations will be frequent enough so as not to unnecessarily impede progress of mining or reclamation.

Topography

Topography of the existing land will be studied in view of the mining or construction activities that are expected to take place. The topography that would follow mining or construction will be predetermined in detail in accordance with the rehabilitation capabilities and land use objectives. Prior to mining, landscape models will be designed to depict a suitable topography based on the amount of overburden, mining methods and land use objectives.

The reshaping of disturbed areas should conform to adjacent terrain and the topography should be reshaped to achieve the best ecological conditions, meet proper drainage and hydrologic conditions and present a pleasing landscape. Unusual, objectionable or unnatural landforms will be avoided.

A major consideration determining topography of the mined areas throughout the region is the overburden to coal ratio. The thick coalbeds of

the area are overlain by thin overburden. Restoration of the land surface to its former elevations is unlikely due to the existing coal to overburden ratios.

The National Academy of Sciences, Study Committee on the Potential for Rehabilitating Lands Surface Mined for Coal in the Western United States, considered that the placement of excavated overburden should offer optimum conditions for land stability, drainage control and revegetation. It was stated that maximum vegetative stability could not be attained on slopes steeper than 33 percent (3:1) and that optimum vegetative stability would require slopes of less than 20 percent (5:1). Various land uses such as wildlife habitat, building sites or farming may tolerate a range of slopes.

Limits on machinery operation and erosion potential are considered essential to the rehabilitation success and maintenance of surface land values. (U.S.D.A. Soil Conservation Service 1971). Some other limitations of various slope classes are listed below:

Level to gentle slopes 0-20 percent (level to 5:1) can be reclaimed for irrigated cropland, urbanization, grazing, wildlife habitat, and recreation, including water impoundments. Various land use values may be limited to some extent within this slope class. Erosion hazards and influence on revegetation is minimal. Mechanical treatment and seeding are not limited by steepness of slope.

Moderately steep slopes 20-33 percent (5:1-3:1) can be reclaimed for grazing, woodland, orchards, recreation, and wildlife habitat, including water impoundments. Light agricultural machinery can be used for rehabilitation.

Moderate erosion hazards are experienced. Revegetation can be successfully established and maintained.

Quite steep slopes 33 percent plus (3:1 and steeper) have limited use potential. Grazing may be permitted and suitable wildlife habitat may be established. Use of machinery is restricted. Revegetation of these slopes may be difficult and severe erosion hazards persist, unless stabilizing structures are used.

Mining equipment used for overburden removal is selected after consideration of type of overburden, thickness of overburden, topography, reclamation requirements and coal production. The shaping of the topography will depend on the types of mining equipment used. The types of equipment contemplated for overburden removal in the region include draglines, power shovels and truck, dozer and scraper, and wheel excavators. Draglines and wheel excavators leave a series of peaked spoil banks or ridges in their wake that require considerable slope reduction and final shaping to achieve an acceptable topography. Scrapers and trucks can discard overburden spoil to a planned grade that requires only minor shaping and grading. Scrapers and truck methods of overburden removal are generally used only where limited amounts of overburden are present.

The placement and final grading of overburden should be accomplished in such a manner that a natural and compatible topography can be achieved. The land form will provide conditions conducive to land surface stability, adequate drainage and surface conditions capable of supporting the desired vegetation. No spoil or cut slope should exceed a 33 percent (3:1) grade after rehabilitation.

Unreclaimed highwall areas may be unsightly and can be a safety hazard to humans, wildlife, and livestock and may limit land use. High walls will be reduced to a slope no steeper than 3:1 during final cut. Erosion control structures such as terraces, water breaks, or other suitable structures may be necessary.

If highwall areas of steeper slopes are necessary to maintain recreation lakes or ponds, protective fencing will be installed above the slope and the approach to the water should not exceed a 3:1 slope.

Drainage

During reshaping and final grading, provision will be made for adequate drainage through a reestablishment of drainage systems that are compatible with the natural drainage systems of adjoining lands.

Accumulation and concentration of salts, toxic elements, or other harmful materials by evaporation of surface waters should not be permitted. These impoundments should be removed if not installed to control pollution of streams or land surface.

Shaping of spoils to manage water is an important aspect of rehabilitation. Where operations could result in acid or saline drainage or sediment damage to adjoining lands, provision will be made for water impoundments. Runoff from spoil areas should be prevented from causing siltation, erosion or other damage to streams or natural water courses. When desirable, downstream erosion control and flood control structures will be required prior to excavations. All water impoundments should be properly designed and constructed for that purpose with suitable outlet structures and spillways installed if appropriate.

Surface hydrology is affected materially by the surface of spoil areas. Spoil surface design is fundamental in intercepting and impeding runoff flows. Runoff from precipitation on spoils is reduced by a roughened surface or increased porosity of spoil materials. Surface manipulation may be used to retard runoff erosion and relieve compaction due to heavy machinery. Terracing, pitting, ditching, listing, deep chiseling, and discing or leaving a roughened surface may be required to reduce excessive runoff, increase soil moisture, and reduce erosion. These practices should not be performed on saline soils since accumulation and concentration of salts would create alkali spots in surface pits and hinder revegetation.

Spoil materials characteristics

Spoils left by mining are mostly a mixture of freshly broken sandstones and shale, and some soil. These spoil materials weather and break into particles that are subject to erosion. Active erosion begins as soon as mining operations expose the spoil materials and occurs most rapidly at the surface.

Overburden materials left as spoils following mining were studied by the USDA Northern Great Plains Research Center. Results showed that the physiochemical properties of materials left as spoils provided a poor environment for vegetative growth.

The various layers of overburden may become mixed upon removal from the mine area. Some of these layers may contain toxic concentrations of elements such as boron, arsenic, and selenium. Analysis of the surface soils and overburden should be made and examined for concentration of toxic materials in relation to stratigraphic occurrence. Mining operations will be planned to provide for the segregation of spoil materials toxic to humans, animals, and vegetation. All exposed coalbeds should be covered by at least three feet of soil material to prevent coal fires and aid revegetation. Waste coal and toxic material should be buried in spoil so as not to inhibit revegetation efforts or be a potential source of pollution to ground or surface waters.

Spoil and surface soil textures influence the amount of moisture available for plant growth. Materials composed largely of sandy material exhibit good aeration and percolation properties but are apt to be droughty. Clay materials compact easily from machinery operations and crust during dry periods. Loams and silty material usually have enough fine materials to hold moisture. The textures of the spoil and soil materials are important to the types of vegetation to be established and the success of revegetation.

Unweathered and unleached spoil materials may contain significant amounts of saline or less likely acid materials which if used as surface material would be a source of pollution to adjoining lands and streams and incapable of supporting significant amounts of plant growth. Excessively acid or alkaline surface or overburden materials will not be used as surface material.

Excessive acid or alkaline surface material that contains toxic or deleterious materials and infertile materials should be buried at a depth that will not reduce reestablishment of adequate vegetative cover. The surface overburden materials should have favorable pH's capable of supporting plant growth.

pH Range 6.0-8.5: This soil class will support a wide variety of climatically adapted plants.

pH greater than 8.5: Plant establishment will be difficult.

pH less than 6.0: Plant establishment will be difficult.

Topsoil

Vegetative establishment cannot succeed without a proper medium for plant growth. The soil-forming process is slow in semiarid climates and topsoil is thin on most hilltops and steep hillsides. However, drainages may contain several feet of alluvial materials.

Beauchamp (1973) considered that topsoil should be used if it is not excessively alkaline or acid since it may contain minerals not present in the overburden spoil. The National Academy of Science Study Committee on the Potential for Rehabilitating Lands Surface Mined for Coal in the Western United States considered that special attention must be given to saving any soil of acceptable quality that exists on a mined site. It was also considered that the values to be derived from adding topsoil are often decreased by stockpiling the soil since one advantage of spreading topsoil is the transplanting of live seeds and plants, especially rhizomatous species.

The entire topsoil structure to the total depth of suitable surface materials will be stripped from all areas where surface disturbance or

coverage by spoil piles is planned and stockpiled for later use or moved directly to a reshaped and prepared rehabilitation area. Topsoil stockpiles should be located in such a manner and place that mixing with subsurface materials will be prevented. If possible, topsoil should be returned immediately to spoil areas that have been graded and shaped to the desired landform and topography since live seeds, rhizomes and soil microorganisms are lost if soil is stockpiled for any length of time. Stripping and respreading of topsoil will be considered as part of the seedbed preparation and will be timed to coincide with this phase of rehabilitation. Reinoculation of stored topsoil may be accomplished by addition of manure or mixing with fresh topsoil.

Mulch

Vegetation can be established only with difficulty on soils being rapidly eroded. Topsoil is characteristically loose, friable and susceptible to both wind and water erosion. Mulches increase infiltration, reduce erosion, soil movement, evaporation and materially enhance revegetation potential especially where poor soil texture conditions exist. Mulches are effective in areas where annual precipitation is between 9 and 14 inches. (National Academy of Science 1974).

Mulch composed of plant residues or other suitable materials will be required as part of seedbed preparation. Acceptable mulching materials are grass, hay, manure, and small grain straw. The mulch material should be applied at two tons or more per acre and anchored by discing, special mulch

machine, or a Colter type machine to a depth of two inches. Other types of mulch material such as straw mat, fine wood fiber, excelsior mesh, plastic mesh, wood chips, gravel and jute mesh can be used. The type, rate, and anchorage of mulch will be specified.

Seeding

Rehabilitation of mixed grass prairie sites has not been difficult when proper seeding has been used. The time of planting is critical for dryland seeding. In the Northern Great Plains area, early spring or late fall seedings are the most reliable. Planting of cool-season grasses that are capable of germinating under very cold conditions and can aestivate when soil moisture is depleted is desirable. (Hodder 1970).

Most land reclamation seeding will take place under dryland conditions unless irrigation water is available. Snow or spring rains provide moisture for germination, initial growth, and establishment. New seedlings, when producing rudimentary root systems and a primary leaf cannot tolerate extended drought. Supplying irrigation water will be required when drought conditions threaten seed germination and plant survival. A suitable water supply will be made available in anticipation of these periodic conditions.

The dryland farming practice of summer fallowing prior to seeding may be required to allow for an adequate accumulation of soil moisture reserves to assure successful vegetation establishment. If such a practice is used adequate erosion controls on unprotected spoil areas (such as surface manipulation and mulching) will be provided.

The species selected for planting must be adapted to local soil and climatic conditions. Native species may be desirable since they have been selected through the process of natural selection and are adapted to local climatic and soil conditions. The unavailability of seed and unreliability of seed sources limit the use of native species.

Hodder 1970, considered that some introduced species possessed superior qualities essential for rapid establishment. Many species of introduced grasses and legumes have been used successfully for stabilizing road cuts and arid ranges (National Academy of Science 1974).

Trees and shrubs may be used on lands being reclaimed for recreation or wildlife habitat. Most woody species should be planted from stock rather than seed for best success. Hodder (1973) lists several innovations or techniques being tested for tree and shrub establishment such as condensation traps, supplemental root transplanting and tubelings. Sites selected for woody species should be capable of supporting this type of vegetation. Some shrubs such as big sagebrush and fourwing saltbush have been seeded successfully. A mixture of native shrubs, trees, grasses, forbs, and introduced species of vegetation may be required on suitable areas where soils and topographic conditions are varied. This mixture would provide a greater opportunity for diverse land uses such as recreation, livestock grazing, and wildlife habitat.

Several seeding methods are available for planting grasses and legumes. Drilling the seed by readily available farm equipment has proven to be the most successful method of planting. Seed distribution and coverage is assured and uniform. Broadcast seeding is satisfactory for small or relatively inaccessible areas. Broadcast seed should be covered by raking, harrowing, or other means.

Rehabilitation of mined land is usually performed under less than ideal farming conditions. Standard seeding rates are usually doubled or increased significantly to allow for seed and seedling mortality due to adverse conditions present on mined lands and other rehabilitation areas. Revegetation failures will occur. The operator will be required to attempt revegetation as many times as necessary to achieve reasonable success.

Fertilizing

Maintenance of vegetation on disturbed areas depends to a large extent upon soil development. Applying manure, sewage sludge, or other organic material will materially enhance the soils capability to supply plants with water and nutrients. Commercial fertilizers are convenient to handle and easy to obtain. The effectiveness of nitrogen fertilizers, however, is dependent on the amount of moisture available. It is generally considered that annual precipitation should be at least 10 to 12 inches to receive benefit from commercial fertilizer on rehabilitation areas. The type of fertilizer and rate of application should be specified when appropriate.

Equipment use

A considerable amount of activity by all types of equipment will occur during construction and mining. Wheeled and tracked equipment will be used in a manner that will minimize surface damages.

Excess disturbance of drainages and high erosion hazard areas will be avoided. During muddy or wet conditions, use of heavy equipment will generally be confined to the construction or mining site.

Rights-of-way, roads

Temporary roads to construction sites or similar developments will be rehabilitated when abandoned. Spoil banks, windrowed soils, debris, and fill material will be replaced in the roadbed and graded to conform to the topography. Cut slopes will be reduced as the fill permits. Closed roads will conform to existing terrain, and be waterbarred and conditioned for revegetation upon abandonment.

Existing roads and trails will be used whenever possible for access purposes. Construction of roads on steep hillsides will be avoided where alternate routes provide adequate access. Ridge tops or level areas usually offer the best access route along with minimizing surface impacts. Drainage will not be blocked by roadfills.

Permanent service roads will be constructed to acceptable standards and maintained in a good condition for vehicle use. Adequate water drainage will be provided to minimize erosion. Erosion of borrow pits by runoff water will be prevented by diverting water at frequent intervals. This may involve construction of waterbreaks, culverts, broadbased drainage dips, graveling or other methods.

Rights-of-way will not be located across high erosion hazard areas or areas of unique values. Construction will be conducted in a manner that will minimize soil erosion. Rights-of-way will not be used for "short cut" trails or roads unless properly constructed for such purposes.

Deep vertical cuts and long fill slopes of clinker pits, roads, pipelines or other construction sites will be graded by reducing slopes, backfilling to conform to the adjacent terrain.

To prevent erosion, waterbreaks, terraces, or diversion ditches should be installed and the water spilled onto areas relatively resistant to erosion.

Waste disposal

Release of waste water containing injurious or deleterious materials will be avoided. Disposal system for solid and liquid wastes will be designed so as not to cause damage to adjoining lands or drainages. Solid waste should be buried or disposed of between impervious overburden layers to prevent its reaching surface water courses or aquifers. Liquid disposal pits containing toxic or deleterious materials will be lined or constructed so as to avoid downward percolation and contamination of ground water aquifers.

Mineral protection

Oil and gas leases are in effect for much of the area. Priorities for mining or drilling for oil and gas on public lands are established by the Conservation Division of the U.S. Geological Survey. Mining operations approaching wells or bore holes that may liberate oil, gas, water, or other fluid substances must be approved in accordance with 30 CFR 211.17 and 30 CFR 211.63. Impacts on oil and gas areas can be mitigated largely by agreements among operators where significant impact on oil well siting or pipeline location arises. In extreme instances of conflict, technology is adequate through directional drilling, drainage practice, recovery of wells lost, pipeline and flowline relocation, pillar recovery, and mining method to adequately mitigate impacts which might arise.

Impacts on uranium bearing rock not of ore grade, clinker, and sand and gravel can be mitigated by stockpiling materials in those cases where mining and construction threaten loss by disturbance of the ground. To the extent these resources are part of the federal mineral estate, operators will be required to segregate, stockpile, or otherwise isolate the resource for possible future use.

Archeological Preservation

Legislative authorities and obligations which guide issuance of federal license to develop the Powder River coal resources are the statute commonly referred to as Antiquities Act of 1906 (34 Stat. 225, 16 U.S.C. 431-433); Wyoming statutes relating to archeological and paleontological sites (sections 36-11 to 56-13 and 18-330.7 W.S. 1957); Wyoming Environmental Quality Act of 1973 (Section 35-502.12(a)(v)); an act for salvage at reservoir sites (74 Stat. 220; 16 U.S.C. 469-469c); an act for historic preservation (80 Stat. 915, 16 U.S.C. 470-470m); National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. 4321 et seq); and Executive Order 11593, May 13, 1971 (36 F.R.-8921).

Both federal and state antiquities acts regulate antiquities excavation and collections, and both protect historical values on public lands. They provide for fine and/or imprisonment for violators of their provisions. The Wyoming Environmental Quality Act protects areas of the state designated unique, irreplacable, historical, archeological, scenic or natural. The reservoir salvage act provides for recovery of historical and archeological data from areas to be inundated by certain water impoundment as a result of federal action. The Historic Preservation Act established a system of historic preservation in the nation and requires that certain federal undertakings be submitted for review by the National Advisory Council on Historic Preservation. NEPA states in Section 101(b)(4) that one objective of national environmental policy is to "preserve important historic, cultural and natural aspects of our national heritage and maintain, wherever possible, an environment which supports diversity and variety of individual choice." Finally, Executive Order 11593 affects federal agencies most intimately in that they are instructed to cooperate with the nonfederal agencies, groups, and individuals and to insure that federal plans and programs contribute to the preservation and enhancement of nonfederally owned historic and cultural

values. Agencies are directed to inventory, evaluate and nominate properties in their jurisdiction to the National Register of Historic Places.

Under the mandate of the Executive Order, federal agencies must insure that until inventories and evaluations are completed, the agencies will use caution to assure that federally owned properties which might qualify for nomination to the National Register of Historic Places are not inadvertently transferred, sold, demolished, or substantially altered and that federal plans and programs contribute to the preservation and enhancement of nonfederally owned sites.

The Antiquities Act of 1906 prohibits damage or excavation of plant and animal antiquities on federal lands without a permit (see 43 CFR Part 3). The Wyoming statutes require that permits be obtained before excavation of any archeological or paleontological deposits on either state or federal public lands (sec. 36-11 W.S. 1957).

Archeological and paleontological values on federal lands will be protected by surveys and salvage excavations. The Wyoming Antiquities Act similarly requires a permit for excavation of antiquities on public lands, permission to be granted by the State Board of Land Commissioners.

The Wyoming Environmental Quality Act requires approval of any application for a mining permit under the provisions of Section 35-502.24 (g)(iv) of this Act to assure that "...the proposed operation will not irreparably harm, destroy, or materially impair any area that has been designated by the Council to be of a unique or irreplaceable, historical, archaeological, scenic or natural value."

Surface surveys for evidence of archeological values in the alluvium are fundamental to establishing responsible stipulations for their protection. Therefore those stipulations in the mining plan and/or permit that require surveys will be followed to insure archeological and paleontological protection.

Historical Values

Authorities for protection and preservation of historic values are the same as those just described for archeologic values. Historic values are protected by the antiquities acts, and surveys conducted to ratify requirements of the reservoir salvage law have included historic research.

To meet responsibilities under these laws and the executive order, the approving federal agencies will insure that mining plans and permits include a program for historic inventory, evaluation and nomination of sites, districts, buildings, and objects, in cooperation and consultation with the State Historic Preservation Officer.

No mining plans, permits or rights-of-way will be approved until the company has coordinated its archeological surveys with the Wyoming State Historic Preservation Officer. Company survey reports will be submitted to the State Historic Preservation Officer with a copy to agencies approving plans and permits. The report will be certified by the Preservation Officer and forwarded to the approving agencies with a statement that surveys have been conducted by competent, professional archeologists and a recommendation for additional surveys to be required before plans and permits are approved. These additional surveys may be necessary if surface evidence indicates further evaluation is necessary. In addition, approvals will be conditioned to require notification to the Area Mining Supervisor of all archeological and paleontological sites discovered during mining prior to disturbance and notification to the appropriate officer of the surface administrating agency of sites discovered during right-of-way construction prior to disturbance. The Antiquities Act of 1906 and Wyoming statutes make it unlawful to excavate sites which are discovered without a permit.

Furthermore, it will be required that the alluvium to be displaced during the mining operation be surveyed and that all surveys be coordinated with the Wyoming State Historic Preservation Officer to insure competent, professional inventories, salvage, and preservation of archeological and paleontological data.

All present and future applicants could share in the cost of establishing a full-time resident basin paleo-archeologist under the supervision of the Wyoming State Historic Preservation Officer. The basin archeologist would aid in reducing lead time and development delays by performing advance surveys for support facilities, educating construction employees, sampling soils, responding to company discoveries, and conducting salvage work.

Recreation

Requests for water impoundments to supply expanded power generating, coal development and domestic uses occupying federal lands and threatening important cultural values and related recreational use, can be granted pending decisions by the State Engineer through the authority contained in the Reservoir Salvage Act of 1960 (74 Stat. 220) and the National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. 4321 et seq).

If a planned reservoir covers federal surface or mineral and its water is designated for another federally approved project, it will first be assessed under the requirements of the National Environmental Policy Act and salvage requirements under the Reservoir Salvage Act. If cultural values are located the "criteria for effect" under Section 106 of the National Historic Preservation Act and Section 2(b) of E.O. 11593 will be initiated by any federal agency joined in the project.

Where scenic, historic, and recreation values are impacted, either on or adjacent to federal land, it will be required that new federal aid highway study locations and alignments complement these resources under the Federal Aid Highway Act of 1973 (Sec. 134(a) P.L. 92-87).

Land Use Planning, Zoning and Controls

A description of the current status of planning, land use controls-constraints and zoning is contained in Chapter IV. The basic situation is that a multiplicity of jurisdictions and agencies are involved in establishing policies, conducting planning, analyses and studies and implementing program actions in response to coal development. The State of Wyoming presently has at least three entities which are in some way involved with policies, planning analyses and studies, and program actions. They are the Land Use Study Commission, Department of Environmental Quality and the Governor's Energy Task Force. However, in the absence of a major overall and restructuring of existing statutory authorities and the land and resource tenure arrangements, it is possible to suggest several mitigative measures and techniques that could have a beneficial effect upon the planning base. Among these are the following:

> The exemption of minerals and minerals development from county planning and zoning should be removed by legislative action while providing for a state override role on planning and zoning for minerals development. The authority in any legislation should go beyond just planning but should include management and enforcement responsibilities. The legislation should foster more joint powers agreement, a greater degree of regional planning, the changing roles for state and local governments in land use controls and the changing awareness or philosophy of land as a resource rather than a commodity.
>
> Encourage a strict enforcement of the provisions and regulations imposed by the Wyoming Environmental Quality Act of 1973 with a

continual monitoring program on industry performance to identify nonperformance problem areas and areas needing further legislative attention.

Amendment to the existing statutes on planning which would change the authorization to effect planning and zoning from a county option basis to a required basis with procedural provisions included to effect compliance.

Institute review and comment cycles at the state and local levels on all types of planning actions and programs.

Encourage an integrated (federal, state and local) approach to all planning programs that relate to land use or resource allocation plans, policies or controls.

Advocate legislation that would increase the level of appropriations for federal agencies to be devoted to planning activities under their existing planning and resource development systems to upgrade the quality and substantive content of plans and intensify the time schedule for earlier completion of plans and implementation programs.

Same with respect to state and local agencies and governments.

Same, but to include additional increases for plan implementation and control functions such as monitoring, enforcement, compliance review, etc.

All future legislation and regulations should require public hearings or other disclosure of proposed federal, state and local plans and programs.

Encourage full public participation, to the maximum extent practicable, by the general public and special interest groups in the planning decision-making processes.

Railroad Construction

Impacts on the region's rail transporation network can be mitigated to a degree under the authority contained in Section 1 (18) of the Interstate Commerce Act (49 Stat. 543, 49 U.S.C. 1 (18)) which requires the prior approval from the Interstate Commerce Commission for the extension or new construction of a line of railroad or the abandonment of operation of a line of railroad. Exempted from this authority are spur, industrial team, switching or side tracks located wholly within one state. Section 1 (18) requires a certificate from the Commission that any construction, extension or abandonment is warranted by the present or future public convenience and necessity.

An intent of the statute is to promote sound economic conditions among individual carriers while recognizing the needs of the shipping public. For an application for new construction, consideration is given to the need for additional rail service in a particular area. If a new line would create essentially duplicative or unnecessary facilities or if the present or future demand for rail transportation is not supported by an area's overall growth and developmental patterns, an authorizing certificate may not be issued. This could arise where a new line, if authorized, would divert substantial portions of the traffic handled over an existing line thereby potentially creating an unprofitable operation which may affect the general adequacy of rail service as well as the financial health of the railroad company. In addition, even if demand patterns may warrant an expansion or additional line, the actual authorized location of such a line would be determined based on a balancing of the relevant economic, technical, and environmental factors. The prior authorization requirement applies to new rail right-of-ways as well as to additional lines in an existing rail right-of-way.

The statutory intent behind prior authorization for railroad abandonments is similar. Here the financial stability of a railroad company may be impaired where a line with declining freight revenues must nevertheless continue to be maintained or rehabilitated. Substantial expenditures may be required on a line with minimal traffic at the expense of maintenance over more highly trafficked lines. This factor, however, must be weighed against the present or potential need of the shipping public for continued rail service and the corresponding effect on the economic vitality of a particular area.

The net effect of the regulatory scheme under the Interstate Commerce Act is thus, to the extent practicable, to promote the availability of rail transportation when and where it is required. As an adjunct to the regulatory functions the Act further provides in Section 1 (19) that public notice of any application for a certificate must be given with a related right to be heard. In this manner the public will be fully informed prior to any major alterations, either additions or deletions, to an area's rail network.

Finally, since applications for construction or abandonment are considered federal actions, the certification process must comply with the provisions of the National Environmental Policy Act of 1969. Environmental values will thereby be incorporated into the pertinent decision making process.

CHAPTER VII

PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

Climate

Since emissions cannot be completely controlled an increase of atmospheric particulates is anticipated.

Vehicle and equipment emissions, airborne dust resulting from coal mining, emissions from power plants and gasification plants will result in a cumulative decline in air quality which may result in an adverse impact to climate which would be unavoidable. Therefore, effects of reduced precipitation on agriculture, mined land rehabilitation and water supplies would also be unavoidable.

Air Quality

Development of coal resources in the region together with related activities will have an unavoidable adverse effect on local and regional air quality. Increases in particulates, sulfur dioxide, nitrogen oxides, trace elements (including radionuclides), and hydrocarbons will occur even though emission controls are employed and air quality standards are enforced. These emissions will decrease the ambient air quality in parts of the Wyoming and Casper intrastate air quality control regions.

Deleterious stack emissions cannot be completely eliminated with existing technology so adverse impact to air quality is unavoidable. Table 1 gives total estimated stack emissions per year for 1980, 1985, and 1990.

Table 1

Estimated Stack Emissions
(tons/year)

Year	Particulates*	Sulfur Dioxide*	Nitrogen Oxides*	Hydrocarbons**
1980#	7,200	70,100	48,000	39,500
1985##	13,700	134,300	90,000	79,000
1990###	16,000	155,700	106,100	79,000

*Assumption: New power plant emissions will meet New Source Performance Standards (NSPS) and Wyoming Air Quality Emission Standards.
**Estimated emission from gasification plants only.
#Total power plant capacity 1,425 megawatts.
##Total power plant capacity 2,700 megawatts.
###Total power plant capacity 3,200 megawatts.

Emissions resulting from daily operation of 24 trains by 1980, 34 by 1985 and 46 by 1990 cannot be avoided. The total emissions as shown in Chapter V, Table 2, cannot be avoided, as there are no emission controls applicable to diesel locomotives. These emissions will add to the cumulative adverse impact on ambient air quality.

Vehicle and equipment emissions will increase during the period 1974 to 1990 even though controls are required. The number of vehicles in Campbell and Converse Counties is projected to increase 43 percent over 1970 levels. Additional miles will be driven as workers commute to the mines, power plants and gasification plants.

An indeterminable increase in airborne dust and similar particulate matter (coal dust, fly ash) resulting from coal development activities will be unavoidable even if all mitigating measures are applied.

Short-term adverse effects are not expected to be significantly harmful to either humans, animals, or vegetation, except possibly during periods of inversions. The probability of a two-day inversion occurrence is 15 times per year, and a five-day inversion is four times a year. (Observations by Marwitz indicate persistent winter inversions -- Hearings Statement 6-26-64.) During these periods, significant short-term adverse effects may occur.

Long-term unavoidable damage to plants, animals and humans from air pollutants may occur and be unavoidable. Even though air quality standards are met by each individual plant or source, the adverse effect of coal development in the study area will be a cumulative decline in air quality. Such a decline would be unavoidable and would begin in 1975, increase during the period of 1975 to 1990 and would continue as long as coal was mined and consumed in the study area.

Table 2 projects increases in air pollutants over the 1970 levels in the Casper and Wyoming intrastate air quality control regions.

Table 2

Total Emission Summary for Casper and Wyoming Intrastate Regions
(tons/year)

	1970	1980		1985		1990	
Type	Total*	Total	Increase**	Total	Increase**	Total	Increase**
Particulates	120,649	128,115	6%	134,733	12%	137,162	14%
Sulfur Dioxide	63,389	134,095	112%	198,564	213%	220,259	248%
Nitrogen Oxides	93,264	145,201	56%	188,943	103%	206,961	122%
Hydrocarbons	67,362	107,862	60%	147,805	119%	148,292	120%

*Combined total for Casper and Wyoming Intrastate Air Quality Control Region adapted from Wyoming Air Quality Standards and Regulations, 1973.

**Percent increase over base year (1970); includes stack and train locomotive emissions.

Topography

A reduction in altitude caused by mining thick coalbeds beneath thin overburden throughout 14,000 acres by 1990 is unavoidable. The decrease in elevation is directly related to the ratio of overburden to the thickness of the coalbed. Greatest decreases in altitude will occur in areas of thinnest overburden and thickest coalbeds. Lowering of altitude on a north-to-south basis will vary from 54 feet at the North Rawhide mine (Carter), 68 feet at Wyodak mine, 36 feet at Black Thunder mine (A.R.Co.), 38 feet at Jacobs Ranch mine (Kerr-McGee), and 28 feet at the proposed Rochelle mine (Peabody).

Destruction of natural features of the landscape is unavoidable. Even though the general topography of the area can be restored at a lower level, cliffs and abrupt breaks, presently a part of the topographic scene, cannot be restored. The exact shape and slope of the present topography is unrestorable.

Changes in topographic features caused by deep cuts along the proposed rail line cannot be avoided. These will affect topography over a small portion of the entire study area. The impact may be very significant on the exact site but overall magnitude will be minor.

Drainage pattern changes and possible creation of new patterns is unavoidable. Even though these changes may be minimized by utilization of sound planning of operations, a certain amount will still occur.

Soils

Disturbance of topsoil on approximately 29,000 acres (0.6 percent of the study area) by 1990 cannot be avoided. Loss of productivity from 9,500 acres of topsoil by 1990 is unavoidable. This acreage will be occupied by roads, railroads, mine buildings, gasification plants, and power plants. The disturbance of topsoil will lower to some degree the natural soil productivity of the area by compaction, mixing natural soils, and causing accelerated soil erosion.

On the area to be strip mined, 14,000 acres by 1990, complete destruction of all soil horizons, parent material, and soil characteristics which have developed over long periods of geologic time cannot be avoided. The present soil biota and soil forming processes will be terminated. Once mining is completed and the area reclaimed, soil development will start again. As an end result of mining, new soils will be formed with characteristics totally unlike the ones existing prior to mining and, during their early geologic life, likely less suitable as substitutes for vegetation growth.

Reduction of soil productivity, permeability and infiltration rates is unavoidable. Increase in erosion and sedimentation rates will occur, but amount of soil loss through time cannot be determined.

Mineral Resources

The mining and removal of coal cannot be avoided under present plans and proposals. Thus, coal mining activity will have an unavoidable adverse effect on the coalbeds. Coal reserves, a nonrenewable mineral commodity, will be depleted. Based on company plans and projections, an estimated 1.5 billion tons of coal will have been mined by 1990 which comprises 12 percent of the estimated economically recoverable strippable coal reserves thus far identified in Campbell and Converse Counties and about 11 percent of the reserves identified in the Northern Great Plains of Wyoming. Loss of minor amounts of coal in mining operations and transportation is unavoidable.

Coal beneath and adjacent to the proposed railroad right-of-way undergoes impact only in that the present value of the coal and/or coal land is decreased because mining is delayed until futher in the future. Although this impact is unavoidable, it is adverse only in the economic sense.

Small amounts of uranium-bearing material might be unavoidably lost through dilution of grade and covering of weakly mineralized rocks in the course of coal mining and construction. The loss would be minor.

Water Resources

The increased use and consumption of water (52,220 acre-feet per year) in the study area by 1990 cannot be avoided. The exact amount which will be consumed and unavailable for other uses is indeterminable and unavoidable. The removal from the study area hydrologic cycle of an estimated 15,000 acre-feet per year by 1990 in the coal slurry pipeline cannot be avoided.

The adverse impact resulting from the interruption of aquifers during mining cannot be avoided. Lowering of water levels of wells, and drying up of springs, seeps, and reduction in streamflow will occur in an area around the mine when aquifers are disrupted. The location and extent of this cone of depression around the mined area will vary depending on various aquifer properties.

If large quantities of ground water are withdrawn from thick sand and shale aquifers, some subsidence may result. Increasing use of ground water as proposed may affect water well levels and discharge of ground water to streamflow. Reduction in flows throughout the study area would be adverse.

Development of lakes, ponds, and pits of water at the completion of mining cannot be avoided where thick coalbeds are mined which have thin overburden levels. This will be adverse to the extent that it depletes streamflows and adds to evaporation loss of water which then is not available for other uses (agriculture, stream fishing habitat).

Changes in water use from agricultural and irrigation uses will occur. These changes, although involving water uses, will actually have adverse, unavoidable impact on farming, grazing, and recreation land uses as well as on fish and wildlife populations.

Reduction in water quality resulting from increased erosion, sedimentation, overtaxed sewage facilities, release of toxic waste to streams, and return of production water to stream channels will take place. The overall reduction in water quality which will take place is unknown.

Vegetation

Existing vegetation will be destroyed on the mined areas, plant sites, housing sites for increased population, transmission line and pipeline rights-of-way, roads and railroad rights-of-way. There will be an unavoidable permanent loss of vegetation on 9,500 acres by 1990 due to construction of permanent facilites. Vegetation will be temporarily destroyed on 14,000 strip mined acres by 1990.

Areas disturbed by rights-of-way will be reclaimed shortly after disturbance. With the semiarid climate prevalent for the study area, successful revegetation on the severely disturbed mined areas is unknown at this time.

All plant succession is unavoidably destroyed at the time of disturbance. Fifty years or more of plant succession will be required for these areas to return to their present state as the existing soil structure and microclimate have been changed and altered.

Adverse impact of stack emissions, especially sulfur dioxide, on vegetation is unknown. The impact, particularly on ponderosa pine, will be unavoidable. Increased population will intensify recreation use which will destroy or decrease the vegetative cover depending on the amount of use an area receives.

Archeological and Paleontological Values

Subsurface material and sites will be damaged or destroyed under the most responsible mining program, with much more lost from surface activities of population expansion.

Some losses, removal of 9,500 acres by 1990, to regional expansion will be expected from lack of surface evidence, time, money, and trained personnel to conduct regional surveys.

Historical Values

Impact on the historical sites: Cantonment Reno, Fort Reno, Hoe Ranch, Portuguese Houses, Powder River Crossing and Red Cloud Agency, from increased population with attendant increase in vandalism and pot hunters cannot be totally avoided. Some damage to these sites will undoubtedly occur as a result of development within the basin.

Visual impacts resulting from construction of rail line, transmission lines, mine facilities, especially silos, and industrial plants are unavoidable. All of the identified historical sites could be impacted visually at some time during the time span required to exhaust the currently economically strippable coal resource.

Some physical impact, despite all precautions, during road building activities, may occur on the following historical sites: Antelope Springs, Minor Bozeman Trail Sites, Crazy Woman Crossing, Seventeen Mile Stage Station and Suggs. Increased access will increase the use pressure on all historical sites and could result in unavoidable damage.

Aesthetics

The change in scenic characteristics throughout the study area cannot be avoided. The major changes will take place in the area of strippable coal reserves. The landscape will be crossed by transmission lines, new road and railroad cut and fill slopes. Vegetative patterns will be altered on rights-of-way and mined areas. New vertical intrusions will be added to the landscape (plant buildings, loading silos).

The change of the study area from a quiet rural setting, with wide open spaces, basically uninhabited to a basin busy with industry and human activity is unavoidable. The quiet solitude and natural peacefulness of the area will be changed.

Wildlife and Fish

Loss of habitat and reduction in populations will occur as a result of coal mining and utilization operations and will be unavoidable. Increased hazards, permanent habitat losses and deteriorated habitat will result in a loss of approximately five percent (850 deer) from the nearly 17,000 deer winter herd in the study area. Approximately 14,500 acres of deer range, including 1,400 acres of key range will be lost.

Antelope will be similarly adversely impacted. Approximately 10,000 acres of year long habitat and an additional 19,000 acres of winter range will be lost, resulting in a nine percent reduction (2,700) of the base population of the study area of 30,300.

In all probability, the 300 head of elk currently using the area will be forced from the area and possibly lost if unable to find other suitable habitat.

Destruction of aquatic habitat and species will occur when streams are altered to allow mining. Amount of loss is indeterminable. Water quality will be reduced, thereby affecting additional aquatic life.

An estimated three percent to four percent (940 to 1,250 birds) of the base sage grouse population in the study area will be lost. This loss will be associated with the loss of 29,750 acres of big sagebrush vegetative type by 1990.

Habitat removal and severe disturbance will result in a direct and permanent loss of sharp tail grouse. Total population numbers are unknown so actual loss cannot be quantified.

Change and elimination of ponds, streams and reservoirs will adversely impact waterfowl. The temporary loss of this water base during mining operations

is unavoidable. Based only upon known aquatic habitat areas where losses appear likely, an estimated loss of 400 to 800 ducks may occur.

Cottontail and jackrabbit populations will be reduced. By 1990, cottontail and jackrabbit populations of about 148 and 101 per square mile, respectively, will be lost on 28 square miles (estimated 7,000 rabbits).

Substantial losses of small mammals will occur. Populations of some rodents such as the deer mouse, least chipmunk, and sagebrush vole will be destroyed or severely reduced on roughly 29,000 acres by 1990.

Recreation

The increased population in the basin will intensify recreation demand. The increased demand could cause deterioration and overuse throughout the area and on existing facilities (Little Thunder Reservoir and Little Powder River Wildlife Area in the National Grasslands, Devils Tower, Keyhole, Guernsey and Glendo State Parks). The generally unavoidable adverse effect is the lowering of recreation quality within the study and adjacent areas.

Agriculture

The permanent cumulative loss of 4,800 acres by 1980, 7,900 acres by 1985, and 9,500 acres by 1990 of agricultural land is unavoidable. The return of agricultural land to production after reclamation depends on rehabilitation success. To determine unavoidable losses, a five percent rehabilitation failure and 10 percent conversion to other uses was assumed. The loss of agricultural production during periods of mining, construction, and rehabilitation cannot be avoided.

Livestock forage

Cumulative forage lost will be 1,515 animal unit months (AUMs) by 1980, 3,435 AUMs by 1985, and 5,067 AUMs by 1990. By 1990, this will amount to four-tenths of one percent of the total forage produced in the study area.

Increased vandalism of livestock watering facilities and fences cannot be avoided. Separation and alteration of ranching operations will occur. Drying up of livestock water sources will occur and ranchers will be inconvenienced by changes in access patterns and use patterns. Increased mortality and molestation of cattle and sheep will take place.

Farming

Cumulative amount of cropland which will be unavoidably lost is 650 acres by 1980, 1,019 acres by 1985, and 1,245 acres by 1990.

Irrigated cropland will be lost due to water right conversion. Total acreage lost due to lack of water is 31,473 acres by 1990.

The unavoidable cropland loss by 1990 would be approximately seven-tenths of one percent of the total available agricultural land within the region.

Transportation Networks

Increased traffic on all existing facilities within the study area cannot be avoided. The increase will begin in the 1975 to 1980 time period, peaking during the 1980 to 1985 interval and probably remaining fairly constant or with very slight increases beyond 1990. This will mean that road maintenance costs and frequency will increase and these costs cannot be avoided.

Temporary inconvenience and poor travel conditions caused during construction of such facilities as the rail line, coal slurry and gasification pipelines are unavoidable. These impacts will be minor and occur only over a short time span. It is impossible to predict the possible increase in train/car accidents. With the number of trains required per day (46 by 1990), the increased probability of these accidents occurring cannot be avoided.

The impact of additional trains on the existing mainline track cannot be avoided. Deterioration of the track and the necessity of having to upgrade the track and impacts associated with this upgrading cannot be avoided. The impacts associated with upgrading will be similar to the impacts discussed in Part II of this statement on construction of the new rail line between Douglas and Gillette.

Socio-Economic Conditions

Population

While the addition of population may not necessarily be adverse, the impact of population growth may generate negative effects. The residual impacts of population can best be discussed by component.

The expected introduction of intensive coal and other industrial development in the Eastern Powder River Coal Basin will induce a regional population increase from 107,364 in 1970 to approximately 167,000 in 1990. The Counties of Campbell and Converse will experience the greatest percentage increases in population. Additionally, over 78 percent of anticipated regional population growth in 1990 will occur in Campbell and Converse Counties. Population in Campbell County will rise from a 1970 level of 12,957 to a 1990 level of 50,400; population in Converse County will grow from a 1970 total of 5,938 to a 1990 total of 15,200.

Employment

A local unavoidable effect will be the attraction of labor from the agriculture, petroleum, and other residentiaries sector into the coal related sectors. This competition for labor will create short-term labor shortages in petroleum and other residentiaries to be filled as coal employment levels off. As a rule, the other residentiaries sector will lag behind coal because newcomers to the area will be expected to arrive for the purpose of coal employment and construction, and not other employment. The labor loss from agriculture will likely be long-term and it may never regain its former employment stature.

The unavoidable effect that large quantities of employment opportunities will be created is largely a consequence of the decision to allow development; such new employment can only be satisfied by importing adequate quantities

of labor into the region. A further consequence in Campbell and Converse Counties will be to hasten the conversion from an agrarian to an industrial economy.

Housing

Industrial development will induce new population that will demand housing. Regional population in 1980 will demand about 46,400 housing units, nearly 9,000 housing units more than the 1970 existing regional stock. As Campbell and Converse Counties will be the locations that receive the greatest population growth, housing stock in Campbell and Converse Counties by 1980 will need to expand by factors of 2.4 and 2.0, respectively, to meet the anticipated demand. Regional housing demand in 1990 will increase to 53,500 units which is 16,000 more than the 1970 stock. Housing demand will grow in Campbell County from 9,500 units in 1980 to 14,800 units in 1990, while housing demand will expand in Converse County from 4,400 units in 1980 to 5,100 units in 1990. The induced population will demand housing which does not now exist.

As housing probably will not be immediately available, the adverse impact of the incoming population having to accept inferior quality housing cannot be avoided.

Education

The impacts on public education as discussed in the Impacts Section are unavoidable. If coal resources are developed, the region will realize a substantial growth in population, which includes school age children. Public school districts, especially in Campbell and Converse Counties, would realize unavoidable increases in student enrollments, which in turn would impact existing school enrollment capacities and full-time teaching staffs. By 1990, Campbell County is projected to have a 8,360 pupil enrollment over

present capacity and need 426 more full-time teachers. Converse County would experience a similar situation although of a lesser magnitude. Converse County by 1990 would have a pupil enrollment of 1,280 over present capacity and need for 91 additional full-time teachers.

If increasing enrollments are not accommodated adequately, the following impacts could result:

1. Overcrowded classrooms in existing schools;
2. Student-teacher ratio imbalance;
3. Use of temporary structures (mobile trailers, modular units) for classrooms because of overcrowded and inadequate facilities;
4. Operating certain schools on a double session basis;
5. Inter-county bussing of students;
6. Reduction in quality of education.

Health and social services

Campbell and Converse Counties will experience an unavoidable increase in demand on their health and social services. There will not be enough physicians, dentists, professional nurses and other social workers to meet the demand. Quality of health care would be adversely reduced. Even though there may be sufficient facilities for the sick to be treated in, people would experience longer waiting periods for treatment. With the rapid population expansion and lack of sanitarians, public health and safety hazards may increase, affecting the entire regional population.

Law enforcement

The impacts on law enforcement as discussed in the Impact Section are unavoidable. If coal is developed, the regional population will expand, creating

a need for increases in police manpower and facilities. The demand for increases in full-time sheriff personnel and full-time municipal policemen is unavoidable.

By 1990, Campbell County would experience a demand for a total of 50 sheriff personnel, a deficit of 42 based on presently available personnel. Converse County by 1990 would have a demand for a total of 15 sheriff personnel, 9 over the number presently on the force. Municipal police departments would experience the same type of increased demand. The Gillette department would have a deficit of 31 people and 11 patrol vehicles by 1990. Douglas would have a deficit of 7 people and 2 patrol vehicles by 1990.

With or without increases in law enforcement personnel, crime incidence will most likely rise. The magnitude of this rise is dependent upon too many variables, which make crime level predictions very difficult and nearly impossible. If adequate levels of enforcement personnel are not provided, intolerable conditions could be encountered in some areas.

Fire protection

Unless expansion is undertaken by communities, deficiencies in water pumping capacity will have the unavoidable effect of diminishing a community's ability to adequately meet hazardous fire conditions. Greater structural fire damage will result, and ability to respond to simultaneous fires will be diminished.

Water and sewer facilities

Water

Current treatment facilities will be unable to meet the projected demand. By 1990, Gillette will have a treatment deficiency of 12.2 million

gallons per day and Douglas would have deficit of 2.2 million gallons per day. The present distribution system would be inadequate for both of these communities by 1980. Adverse unavoidable impacts could occur (use of low quality water, increased sickness, poor health) from not providing adequate water treatment and distribution systems.

Sewer

Current collection and treatment facilities for Douglas and Gillette will be overutilized by 1980. In 1990, Gillette will have a collection capability deficiency of 2.9 million gallons per day and a treatment deficiency of 3.3 million gallons per day. Douglas, by 1990, will experience a deficiency of 700,000 gallons per day in its collection and treatment facilities.

Overuse of the sewage facilities could result in the unavoidable adverse impact of more sewage being dumped into stream channels (Donkey Creek, North Platte River).

Utilities

Regardless of the degree of planning, certain impacts may be unavoidable. Douglas is faced with possible telephone service delays if it grows to the north and it may likely incur delays in all types of utility service if a coal gasification plant with its large employment locates nearby. The Cities of Gillette and Newcastle may be faced with a natural gas shortage if a large number of new base hookups are required. The actual extent to which the supposed natural gas shortage exists was not known to the local distributor inasmuch as he in turn purchases his gas from a regional supplier. Distributors to the other communities did not express a similar problem. Present construction material shortages may worsen if utility companies must acquire increasingly larger amounts of materials to satisfy consumer service requests.